ENGINEERING RECORD

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Teaching by Moving Pictures Moving pictures, ten years ago nothing more than an "act" in the vaudeville theaters, have risen above the plane of mere entertainment and are counted as an educational agency. Not only is this true in the sense that picture plays of high merit are presented, but that subjects purely utilitarian are taught. A most interesting and significant application has been made by the Central Railroad of Georgia—in attempting to teach fuel economy by means of the "movies." The views show fire-boxes properly and improperly fired, correct and faulty methods of handling the scoop, and engines underway, indicating wasteful methods by the emission of dense smoke and the popping of safety valves. Though only 15 months old, the pictures have been shown with good results on the Central Georgia, the Union Pacific and the Illinois Central. Without doubt the idea can be extended not only to other branches of railroading but to various phases of outdoor construction. In certain industries they have already been used with much success.

The Last of Its Class We are accustomed to think that steel and concrete are the only materials suitable for large buildings, both the cost and difficulty of securing lumber in large sizes having long ago eliminated wood as a structural material except in falsework, temporary construction and structures of small size. Machinery Hall now being built for the Panama-Pacific Exposition is, therefore, of more than usual interest. With a floor area of more than 8 acres and an extreme height of 135 ft. few engineers would at first thought suggest for its framework any other material than steel. With the Pacific Coast forests at hand, however, offering a wealth of satisfactory lumber at satisfactory prices the engineers found that timber would prove more economical. Using as it does about 7,500,000 ft. b. m. of lumber, it is fairly safe to venture the prediction that it will be the last of great monumental structures to be built of native timber, and we may even hazard the statement that never again will its equal be erected of such material in this country. While, therefore, in its entirety Machinery Hall is not likely to be a precedent, its details, of value to structural engineers, and its classical and singular character warrant the extent of the treatment accorded to it on page 237.

Disfigurement by Billboards Judging superficially, a stranger visiting the business districts of large American cities might well conclude that the formula for building them runs something like this: "Take a number of buildings of assorted heights, mix in haphazard fashion and plaster liberally with gaudy and ugly billboards." If one thing more than another tends to give our cities an uncouth appearance and to imply a lack of architectural culture and good taste it is our hideous outdoor advertising. Even dirty streets do not give so bad an impression, though some people do notice them the sooner because our education in sanitary matters has progressed beyond our education in æsthetics. Last December the Mayor of New York appointed a billboard commission, which, under date of Aug. 1, brought in a report that should in abstract be reprinted by civic-betterment leagues and scattered broadcast throughout the country. The recommendations are much more drastic even than the regulations which became effective in Chicago last year. Briefly, the recommended rules would prohibit all outdoor advertising, except shop signs, in the neighborhood of parks, public buildings and streets of exceptional character, and all large or flashing electric signs in or near residential districts; would limit the size of all outdoor advertising; regulate advertisements on subway and elevated railroad stations; prohibit roof signs in residential districts; grant local option to determine whether outdoor advertising will be prohibited in certain districts; exact taxes for outdoor advertising and, finally, provide a censorship both as to moral tone and æsthetic qualities. Unfortunately these recommendations are but the beginning of the fight, for their adoption will require not only building code amendment but also amendment of the state constitution, the latter being needed to secure full control on æsthetic grounds alone. All who are sincerely interested in general civic improvement—and their number has grown prodigiously in fifteen years—will join the Engineering Record in the hope that New York will adopt the recommendations. Such action would improve the appearance of the city and serve as an example to other cities. Chicago acted courageously in 1911 and has pointed the way for New York to go a step farther.

Divided Responsibility After reading the official reports of the recent wreck on the Pennsylvania Railroad at Tyrone, Pa., one is strongly inclined to doubt whether two heads are better than one in the cab of a railway locomotive. Very often when one man has failed to see or observe signals it is contended that the only thing to do is to put two men in the cab. The Tyrone case, as far as it goes, shows that this would be useless if not dangerous; for there were two men in the engine which ran by two signals and crashed into a standing passenger train. One of them was a road foreman of engines and the other was an experienced engineer with a good record. On the Pennsylvania a road foreman is supposed to be working while he is riding on an engine—he is not merely a free passenger with nothing to do. Yet in this instance he and the engineer failed to observe, or ran by, a distant signal set at caution 4000 ft. from a home signal; then by a home signal set at stop position, and then into the rear end of a train standing 1150 ft. beyond the stop signal. Mixed up in the collision, in which more than 150 people were injured, was an inspection party, including the signal engineer of the company. We have his evidence as well as that of the signal operator and half a dozen outsiders that the distant signal was at caution and the near signal at stop when the doubly manned engine passed them. These conditions are radically different from those of the Stamford wreck on the New Haven. There the engineman claimed to have tried unavailingly to stop after observing signals against him. The colliding Pennsylvania trains at Tyrone were all-steel cars and no one was killed. There was, therefore, little excitement over the wreck, but there is more to be learned from it than from the Stamford disaster. Among these things the most obvious is that two men, both experienced and thought to be thoroughly reliable, were proved to be no better than—in fact not as good as—one man so far as signal observance is concerned. This is due, in the opinion of railroad men, to the fact that with a division of responsibility there is actually less care exercised than when one man knows that entire responsibility is on his shoulders. To draw general conclusions from a single accident would not be justified were it not that this accident so strikingly confirms human experience. Evidently those who have recommended two men on engines as a cure for railroad wrecks caused by failure to observe signals must look for another and more efficacious remedy.

Titles of Railroad Engineers Lack of distinctive titles or designations, especially among the younger men, is a source of dissatisfaction to railroad engineers. An errand boy may get a job trimming and coloring blueprints, and with it the title of "draftsman." In the same room a technical graduate with years of experience, working out involved problems, will have the same title; or men who have been in the service two or three years may be honored by the title of "transitman," whether they work indoors or in the field. In a squad working out the architectural and structural details of an important terminal, involving reinforced-concrete foundations and fireproof-building construction, the man in charge is a "transitman"; so are all his men except one, who is a "draftsman." One of the transitmen does not profess to know what a transit looks like; he is simply an office man. On some roads "assistant engineer" is a coveted title; on others it means very little. The lack of uniformity extends, of course, to the higher positions. A division engineer may handle maintenance only; he may be on construction and have nothing to do with maintenance, or he may be the czar of all engineering work on his division. On one road the "office engineer" formerly confined himself to dealings with contractors, the opening of bids and the like. Within a year this work was delegated to a man with a different title, and a new "office engineer" took charge of the preparation of plans, estimates and specifications. The committee on rules and organization of the American Railway Engineering Association has gone rather exhaustively into the handling of track forces on maintenance, the subdivision of the work and the designation and duties of the minor officials. It would seem worth while for this committee to investigate the organization of the engineering forces and evolve a system of titles which will indicate the character of each man's work.

Good-Roads Days The "Good-Roads Days" in Missouri last week attracted attention the country over. Newspapers gave much space to accounts of the valiant labors of the commander-in-chief, the governor of the state, and of his army of road workers. Nor were they unmindful of the pilgrimage of the governor of Kansas in order to have a hand in the work. Judging by most reports, the chief benefit deemed to be derived consists in the actual work done—the number of miles graded and gravelled. Undoubtedly 50,000 men—the number reported as participating—can, if properly directed, effect a temporary improvement in two working days; but those whose interest in highways is not spasmodic or hysterical will question whether there are not other advantages—and disadvantages as well. As an advantage certainly can be set down the increased interest in good roads, while, in addition, the demonstration of the comparatively large results for a small expenditure of energy should go down on the credit side of the "Good-Roads Days" account. Surely it should now be easier to get sane highway legislation through the Missouri Legislature. But there are items to be entered on the debit side. The chief one is that these days will engender the notion that highway work is extremely simple and that it consists solely in filling up ruts. The value of drainage—so essential to good dirt roads—is likely to be overlooked. Moreover, spasmodic efforts, especially when attended by enthusiasm, are likely to leave the impression that occasional efforts are sufficient to keep roads in good condition. Bitter experience should teach road users that such is not the case, but the omission in highway laws of provision for maintenance is so general that something besides occasional good-roads days is necessary to inculcate sound ideas on highway management. Until the people at large have sound ideas on the subject, proper recognition of maintenance will not be accorded by their legislative representatives. While, therefore, there are some benefits to be derived from good-roads days, they are not an unmixed evil unless accompanied by an educational propaganda. If with the campaign for bringing out the men there be combined the distribution of short, simple leaflets emphasizing the essentials for good dirt roads, the value of the good-roads day will be much enhanced. In the end, however, it must be admitted that no satisfactory road system will ever be evolved from these spurts. A competent paid organization must eventually be established in every county.

Comprehensive Investigation of the Chicago Terminal Situation

That private citizens of Chicago are willing to subscribe $100,000, if necessary, to investigate the whole railroad terminal situation, and have already retained an engineer under whose direction $25,000 will be spent to make sufficient preliminary studies to determine whether the remaining $75,000 can be spent with profit, is one of the most gratifying indications that hard-headed, far-seeing modern business men realize the economic necessity of sound, comprehensive engineering advice on the largest of public problems with which Chicago has to cope. Mr. Bion J. Arnold, the engineer selected, expects that there will be harmony with, and not antagonism to, the work which Mr. John F. Wallace has undertaken for the city on one phase of the problem—the location of the freight and passenger terminals of the Pennsylvania Railroad and allied interests. He states that he enters the work without any preconceived ideas, and has given the committee to understand that he will accept suggestions, but proposes to solve the problem only after studying all of the terminals with a view to co-ordinating them in such a manner as to get the best and most economical distribution of freight and passenger traffic for the city as a whole.

In a pamphlet distributed to those interested in the movement attention is called to the lack of any comprehensive investigation and to the imperative need for one at the present time in view of the proposal of the Pennsylvania Railroad for terminals on the west side. Further, it is stated that no plans should be adopted for these improvements which would seriously interfere with carrying out the most desirable comprehensive solution of the terminal situation in Chicago. With the present funds it is proposed to make a preliminary study of sufficient magnitude to enable the citizens' executive committee—which, by the way, contains the name of a well-known consulting engineer along with those of financiers and business men—to agree or disagree intelligently with the Wallace report. In the latter event it is the intention to raise the remaining $75,000 and ask the city to delay action for a year.

It is not at all improbable that the preliminary study by Mr. Arnold will show that further investigation will be a waste of time and money and, therefore, that the Wallace report should be accepted without delay. Nevertheless, the investigation even in that event will have been well worth while, for based on independent studies and reviewing the whole situation comprehensively with a different personal equation it will give a stamp of finality which will be accepted without question by financial and business interests and by the public at large. If the reports are not in agreement there will be good reason for delaying action until the experts can thresh out the differences. The issues at stake are too large to be settled by fiat without weighing the objections of a competent investigator.

Incidentally it is worth remarking that this independent investigation would probably not have been undertaken had the city council's committee followed the course suggested by this journal on June 28, and employed not one expert but "a competent body of experts."

Co-ordination of Engineering Research

To get rid of unnecessary duplication of effort is one of the first objects of the efficiency expert in every field of human industry. In the pursuit of this ideal the division of labor has been carried to extraordinary lengths and specialization has attained a development never before equalled. Close observers of industrial progress are beginning to realize, however, that specialization is in the last analysis a rather arbitrary matter, and that an interdependence exists between the various practical arts which demands anything but narrow knowledge of simple specialties for the most enduring success. It is increasingly essential for the expert in any one field to keep in touch with progress in even distantly related lines of work, and in the engineering profession in particular the catholicity of its interests, its uncounted points of contact with the business and scientific worlds, and the overlapping of its equipment and methods in different branches exact devotion to the broad outlook no less than faithful attention to details from the successful practitioner. It is this situation which commends to the attention of the engineer every carefully considered suggestion aimed to facilitate his knowledge of significant progress in the domain of physical science, and in this connection a paper on "Engineering Research and Its Co-ordination," read by Mr. G. H. Roberts at the July meeting of the Institution of Mechanical Engineers at Cambridge, England, is of special interest.

The author points out that no definite and generally recognized system has been formulated for making known to the profession the results of numerous private researches and experiments constantly in progress and emphasizes the need of a sort of worldwide docket of engineering research which will constitute a clearing house of information as to the kind of investigations in hand, the objects sought, and the results attained. The desirability of accomplishing this end needs little argument, for if it could be brought about it would undoubtedly save a great deal of time and money and vastly enhance the efficiency with which engineering research is conducted in different parts of the world. The day is certainly far distant when all duplication of research will be a thing of the past—for the conditions surrounding investigations will always be enormously varied, and the personal equations and laboratory equipment of the investigators will often demand independent observation; but the fundamental point is to acquaint the profession as a whole with the research activities of individuals and organizations, and once this is done the saving in effort will repay the cost many times over every year.

To specify in detail how this problem can best be solved is not feasible at the present moment, but the matter can be discussed to great advantage by engineers and should receive the best thought of many minds before any elaborate scheme is attempted. Mr. Roberts suggests that the Institution of Mechanical Engineers may be the proper clearing house of data and touches upon the possibilities of ultimately guiding research by the committee method. To make his proposals definite he presents as a nucleus about a dozen pages of tests made at the Woolwich Arsenal upon the mechanical properties of some 75 varieties of woods and 23 alloys; reviews the recommendations of the Standards Committee in regard to the proportions of test pieces, and briefly discusses the unification of methods of reporting. In view of the magnitude of the subject, however, and particularly because of the overwhelming mass of data in process of accumulation throughout the engineering world, it is open to debate whether the best way to start this campaign is not by the preparation of an index bibliography of current research, perhaps subdivided among the national engineering societies or else compiled in a central bureau reporting back to the great engineering organizations supporting it and contributing to its accumulations. There are, of course, many researches which those who meet their cost legitimately prefer to keep in private hands; but there is a huge volume of investigation under way to which restrictions upon publicity do not apply, and if the results of such work can be disseminated through an efficient organization a great advance will be made in the methods and spirit of modern engineering research.

Higher Efficiency through Consideration for Labor

One of the big railway systems of the East recently awakened to the fact that it had something like 7000 Italians in its employ about whom it knew little or nothing. In a vague way it had observed for some years back the replacement of Irish laborers by Italians, and then the gradual reduction in numbers of the latter, accompanied by an increase of Slav labor. With some of the Italian gangs there had been no little trouble, and there was reason to find fault with the results of Italian labor at large. There was no doubt, however, that whether or not this kind of labor was theoretically the most desirable it certainly was the most desirable that could be obtained under present conditions. It was apparent, therefore, that it was wise for the road to conserve this source of supply, to retain the men it had and to draw others into its service.

It was when the management started out to discover what it could do to carry out these aims that it found out how little it knew about the Italians or other classes of day laborers on its lines, outside of a few maintenance gangs of picked men. In the main they existed merely as a string of numbers on forty-odd payrolls. How they lived, where they lived, what became of them when they were laid off, what were their complaints, what were the competitive labor conditions that affected them—all these and other questions were unanswerable on the basis of any information in the possession of the general or division offices. In this situation the management of the road in question thought it worth while to engage an Italian—a Yale man who had an interest in social problems—to make a study of his countrymen employed on the railway's lines and to recommend methods of establishing an understanding between these employees and their employer.

On this road esprit de corps is carefully nurtured, and it is now intended that the Italian laborer shall be made to feel that he is one of the family; that his welfare is a matter of concern to the management. First of all it will be necessary to make him realize that he works for a certain company that can and wants to look after him. At present he is too often conscious only of the fact that he works for a "boss," not for an institution, and the "boss" has rarely tried to make the employee feel that anybody takes the slightest interest in him—not even enough interest to find out his name

If this railroad, spread out as it is over a dozen states, finds it desirable to establish a good understanding with its foreign labor, it suggests that the private employer, on construction work in particular, but in manufacturing and other plants as well, may profitably adopt the same policy. It is a commonplace that the best service is obtainable only from loyal workers, and obviously loyalty is not to be expected without at least an acquaintance. A friendly understanding usually exists between employer and employed down to a certain grade. The foreign laborer is too often considered to be below the deadline of acquaintance, and left out of the fold he has flocked by himself, unconsidered, aloof and too often looking for trouble.

Without generalizing too much it is safe to say that there is no class of labor that responds more readily to friendly treatment than does the Italian. This may be disputed by those who judge their men only through experience with padrone-hired gangs. But the employers who insist that their foremen and other subordinates shall take the trouble to know their men tell a different story. On the New York tunnel work of the Pennsylvania Railroad the most efficient gangs—those which constantly set the pace for rapid work—were the Italians employed by one contractor. Gangs of the same mixed composition employed by other contractors were constantly changing and were always relatively inefficient. The difference was due to different treatment of the men. The contractor who was successful with Italians and negroes treated them as men, not simply as numbered sand-hogs, and the men responded accordingly. The sand-hogs also lived up (or down) to their names, and the results were unsatisfactory to everybody concerned. The lesson of this is simply that good treatment of the lower strata of employees is just as necessary, on grounds of expediency as well as humanity, as is a good understanding between the employer and the higher ranks of employees.

Abundance and Water Waste

The completion of the Catskill Aqueduct will likely bring with it a new and difficult problem, quite different from any which has thus far confronted the engineers of New York City's water supplies. As was pointed out by Mr. John R. Freeman in his report to the comptroller in 1900, there exists in New York a condition which tends materially to restrict water waste. Over large areas many of the buildings are so tall that the low street main pressures do not raise the water above the lower stories. Consequently small pumps are operated by the owners of buildings; and, since extensive use means high cost for pumps and pumping, self-interest makes for economy. Within a few years, however, the introduction of Catskill Mountain water and improvements in the distribution system will result in much higher pressures in many parts of the city. Great numbers of house pumps will become unnecessary. What then—and this is the problem—will replace their beneficent restraint upon water waste? Furthermore, other things remaining as before, higher pressures naturally result in greater waste, while knowledge that an additional supply has become available creates a feeling of abundance, leading in turn to more liberal and less careful use.

In this predicament many engineers would quite naturally turn to meters. If they were used the greater consumption would increase the water department's income and more rapidly swell the fund for defraying the cost of the works. Reasonable meter charges would not prevent increased use, but would apply the brakes gently to growing extravagance.

Other expedients will naturally be considered. The desirability of encouraging abundant use when the supply is more than ample raises some difficulties which would seem to eliminate such encouragement entirely. Nevertheless, in a problem of such magnitude, having so many factors, the possibilities of all reasonable schemes are worthy of study. It would seem good business policy to sell as much water as possible—provided meters are used—immediately upon the completion of a new supply. The revenues of the department would thus be considerably increased. As the demand approaches the capacity of the works it would become necessary to repress extravagance, even if the water is paid for, and eventually to discourage too liberal use. This could be done by raising the rates; but the mere suggestion of such a plan brings to the minds of officials of both private and public utility organizations newspaper campaigns of recrimination and wide denunciation from the public. In a private competitive business the raising of prices may be attended with little difficulty, but it is by no means easy for the public utility. Nevertheless, there is a sound basis for the proposal. The objection might be overcome if upon the first use of the new supply notice were given that the rates would be increased to certain definite figures at the end of five and of ten years, or at whatever periods local conditions may make desirable.

Other methods of curtailment of water consumption successfully used in New York two years ago were the enlistment of the co-operation of the citizens by a campaign through the daily press and house to house visitations by inspectors in order to locate leaky fixtures. Should occasion again arise for curtailment these methods could undoubtedly be again employed with success.

The installation of meters and the determination of a schedule of equitable and reasonable meter rates to fit the complex conditions of a great metropolitan community such as New York are not tasks for a mere stripling in waterworks management. One borough of the city has an average population density of 90,000 per square mile, and is chiefly occupied by great office and loft buildings, wholesale and retail stores, factories, hotels, and apartment houses containing twenty to one hundred families each. In another borough the population averages only 1200 per square mile, and there are thousands of acres of market gardens. In the five boroughs dwell some new immigrants, scarcely civilized, endeavoring to subsist on less than a living income. Here also are hundreds of homes of the greatest comfort and luxury. The former's miserable tenements have almost no conveniences for the use of water; in the latter are all the appliances produced by the modern plumbing manufacturer's skill. In some districts the number of consumers per mile of main is quite low; in others, the greatest to be found anywhere. In such a community it is desirable to have not only sliding schedules on quantity demanded for industrial purposes, but also to adjust the domestic minimum charges to fit various standards of home life, according to the character of the various districts. Exact adjustments are, of course, impracticable, but a reasonably approximate solution of the problem should be obtained by close and intelligent consideration, and more or less frequent readjustments.

An additional difficulty would, doubtless, arise from popular opposition to meters. Misunderstanding of the effect of meters upon consumption is widespread even among people of intelligence, as was evidenced by a statement of a mayor of one of the large Eastern cities some time ago. He advanced the threadbare objection that the use of meters would, from a sense of economy, undesirably curtail the use of water and lead to poor sanitary conditions. The possible reduction of the use of water to the unsanitary limit, as is well known, is generally met by setting a minimum charge per quarter or per year, for which is supplied a sufficient quantity to meet the ordinary needs of an average family in moderate circumstances. Then there is no financial temptation to use less than the minimum for which the charge is made. If more is used it is paid for by the party enjoying such use, and waste automatically brings its own penalty. While these matters are understood among professional men there reiteration and emphasis are necessary when erroneous ideas are enunciated and newspaper and popular opposition is aroused against the installation of meters. The task before the engineers in charge of New York's water supplies is but one of the many problems of municipal engineering in which the attitude of the public is an important factor in the success of a technical measure.

Unit Subway Construction in Kansas City

Casting the Separate Members at a Specially Built Slab Plant

In rehabilitating the old Kansas City Belt Line and placing it in shape suitable to carry high-speed passenger trains all crossings at grade are to be eliminated and grades reduced from 1.5 to 0.9 per cent. For 2 miles east of Grand Avenue the existing cut is being lowered, the present maximum of 42 ft. at Woodland Avenue being increased to 80 ft. As outlined in the Engineering Record of Nov. 2, 1912, the tracks of the Kansas City Terminal Railway Company will connect with all railroads, bringing passengers to the union station now under construction at Baltimore Avenue and Twenty-third Street.

In the numerous grade separations, some of which are reconstructions, there are twelve subways built of concrete floorslabs, girders and columns molded at a plant miles away from the site. Unit construction was used to expedite the work when initiated, to permit concentration of the raw material and to make it possible to use concrete which had set at least three months.

Derrick Setting Cross Girders

Unit stresses were figured from a Cooper's E-60 engine loading plus 50 per cent for impact on the deck. Any impact over 50 per cent was assumed to be absorbed by the ballast. The slabs were designed for 50 per cent impact and the cross-girders for 25 per cent, but no impact was figured on the abutments or columns.

Maximum loading on the slabs immediately after setting up in place was due to a crane weighing 110 tons handling a 40-ton slab, plus approximately 40 tons dead load of the slabs. Columns were designed to support 800 lb. per square inch, the loading being figured for that portion of the column inside of the steel-reinforcing basket. A 1:2:4 mixture of concrete was used in all slabs, cross-girders and columns, allowing 750 lb. per square inch for concrete in compression and 15,000 lb. per square inch for steel in tension.

Column Details

The columns are 25 in. square at the top under the 3-ft. square capital and were given a batter of 3/16 in. per foot. They vary in height from 9 to 12 ft. The reinforcement consists of four 4 x 4-in., or 6 x 6-in. angles of sufficient thickness to take the entire load at the elastic limit of the material. As set, the angles are covered with at least 3 in. of concrete. At the bottom they are riveted to the inside upturned legs of four angles, which rest on the molding board. About 2 ft. apart vertically they are held together by 6 x ⅜-in. steel batten plates and at the top by a ring of angles. Triangle-mesh reinforcement is wrapped around the basket and separated from it by a 1-in. bar placed at each corner. At each bottom corner a block was inserted over the 1¼-in. holes in the horizontal legs of the angles. The holes provide for 1-in. holding-down bolts, used during erection only, to preserve alignment and prevent any tendency to kick out due to eccentric loading. Corners of the columns are round to a 1⅝-in. radius.

The floorslabs are usually 3 ft. thick, and vary in length and width up to 27 ft. long by 5 ft. wide, the maximum weight being 40 tons. Ordinarily the cross-girders are 2½ ft. wide by 4½ ft. deep, averaging about 14 ft. long. They are reinforced in the usual way, a portion of the rods being bent up at the ends to care for shear in addition to the stirrups.

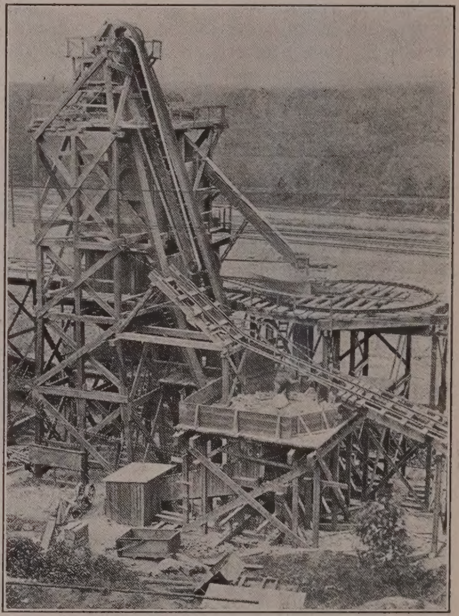
For handling the slabs U-shaped stirrups of 1½-in. square bars were embedded in the concrete flush with the top. The length of the U is about 13½ in. and the width between the legs, 4 in. Three ¾-in. bars were laid over the bent ends of the legs to further anchor the stirrup. All sides and ends of the slabs were given a total batter of ½ in., the slabs thus touching each other at the bottom only, if at all. After the slabs were set in place a sawed strip of timber shaped to fit the 1-in. chamfered lower edges was drawn up tight by wires, which were tightened from above by twisting with a stick. Grout was then filled in.

For the purpose of increasing the apparent height of the subways, the ends of the cross-girders were finished as column capitals drawing in the sides to the size of the top of the column shaft.

As shown in one of the photographs, the slab over the sidewalk is made much shallower than that over the roadway, and raised by the use of a base to the height of the roadway units so as to simplify the waterproofing.

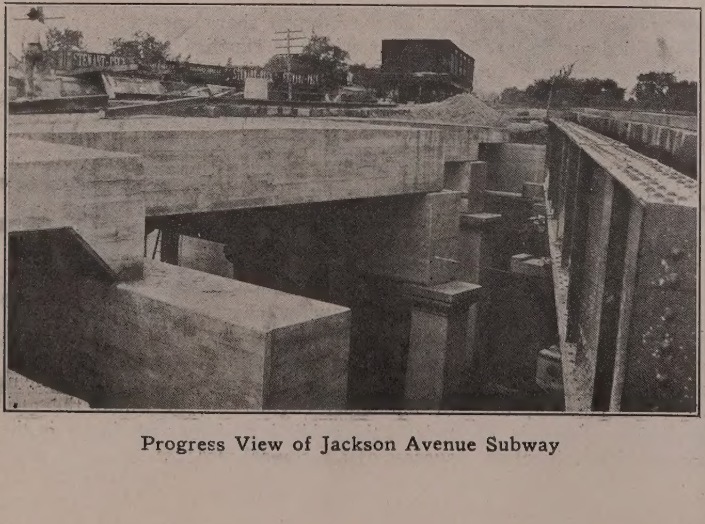
Jackson Avenue Subway

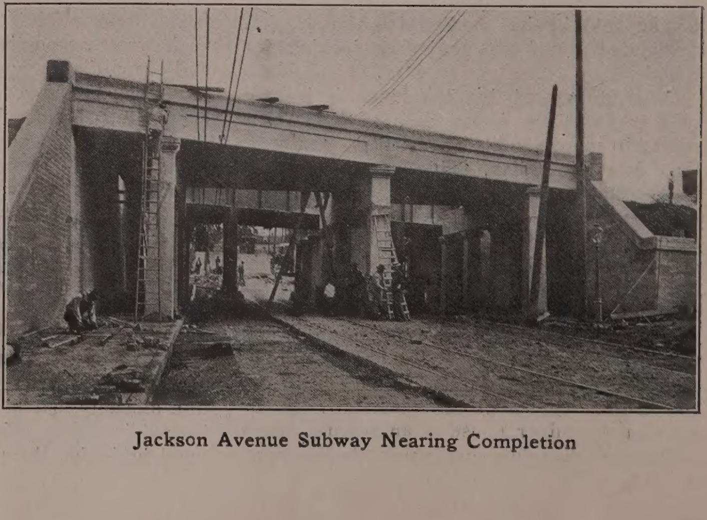
Practically all of the subways are built on a skew. At Jackson Avenue, one of the first subways completed, the width at right angles to the center line of the right-of-way is 72 ft. Between abutments it is 60 ft. A headway of 14 ft. is provided above the car tracks in the 20-ft. roadways. Slabs are laid squarely from girder to girder or to the abutments, except at the ends, where three fan-shaped slabs are used just inside the panelled fascia girder.

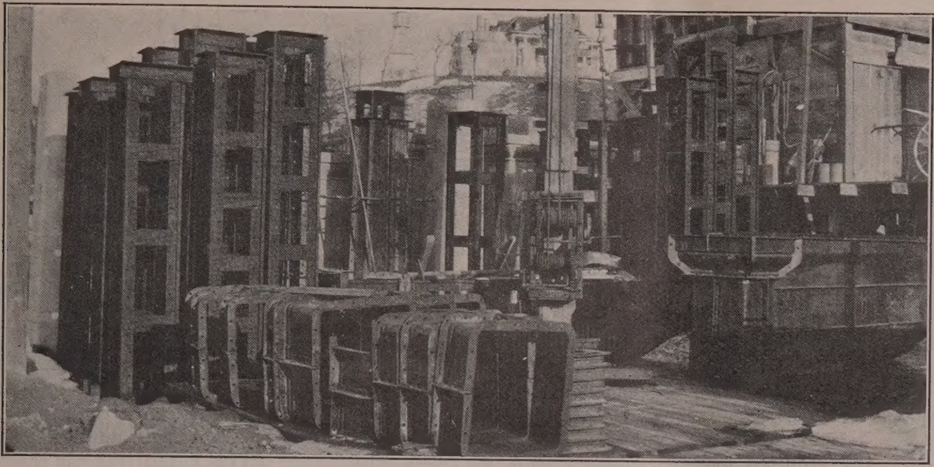

General View of Rock Crusher

As traffic had to be maintained during construction, pile bents were inserted under the plate girders of the old bridge, carrying two tracks, which were shifted from one side to the other after one-half of the floor slabs had been dropped into position.

Placing the slabs and other units was accomplished by a 120-ton Industrial wrecking crane, which was capable of handling the largest


Progress View of Jackson Avenue Subway

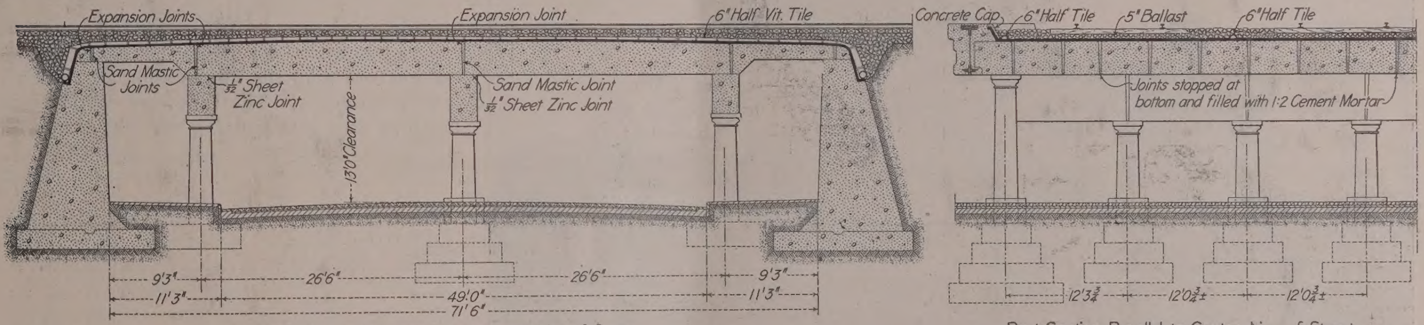

Jackson Avenue Subway Nearing Completion



View of Column-Casting Platform and Part of Mixer Plant
Note shaft forms and steel baskets

slabs, weighing 40 tons, with a radius of 34 ft. A special link shown herewith was used to pick up the slabs, great care being taken to have the dead weight distributed as nearly equally as possible.

As a first consideration in waterproofing the subways, the design provided for the rapid removal of the water by sloping the deck slabs from the center toward each abutment with a total drop of 6 in. After all the taper joints between slabs were grouted and the concrete thoroughly cleaned a brush coat of asphalt primer was applied. This was covered with a ⅛-in. coat of heated waterproofing material. A four-ply burlap and a one-ply wool-felt (the latter to prevent the top coating of mastic from drawing the waterproofing material from the burlap) were then carefully laid and covered by another coat of waterproofing material. Over this was 1 in. of mastic, composed of 4 parts stone screenings and 1 part asphalt, and 1 in. of waterproofing material. On top of all, for quick drainage, there was placed 1 in. of limestone screenings. A notch was left in the fascia slabs, or incasement of the fascia girders 15 in. above the top of the slabs, into which the ends of the burlap strips were laid and sealed with asphalt. Crushed stone was filled in back of the abutments to remove the seepage to a tile drainage system leading to the sewer.



Section at Right Angles to Center Line of Street

Part Section Parallel to Center Line of Street

Typical Transverse and Longitudinal Subway Sections, Showing Expansion Joints and Waterproofing

Slab Plant

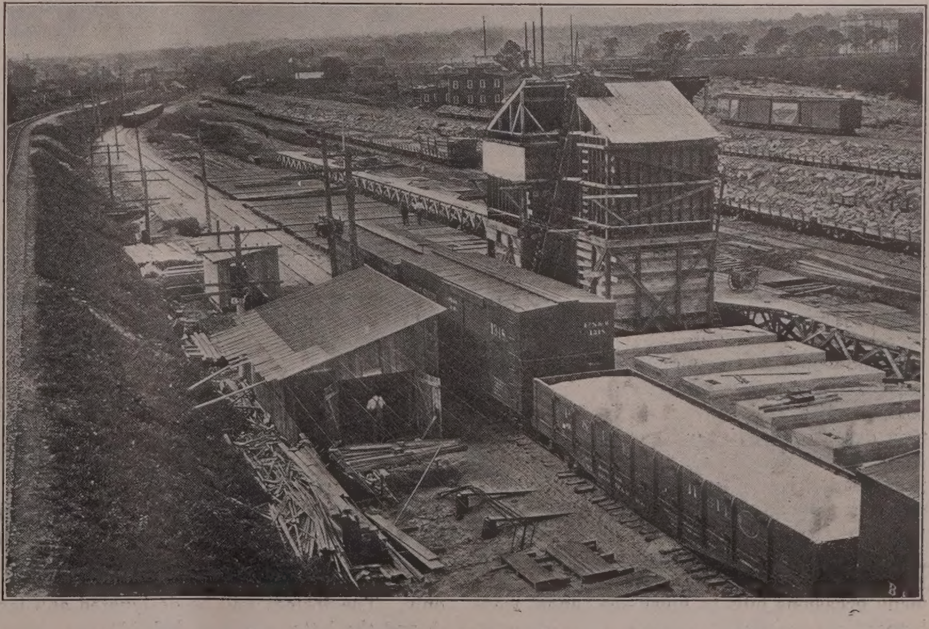
The slab plant is located near a quarry opened especially by the terminal company near the eastern city limits to furnish material for the work. It comprises a central mixer outfit from which 9-ft. runways, 6 ft. above ground, extend 300 ft. in each direction between platforms on which the slabs are cast. Space to the west of the plant is utilized as a storage-curing yard.

In the mixer house is an 18-cu. ft. Chain-Belt mixer fed by gravity from two material bins. The aggregate is dumped from standard-gage cars into the boot of a conveyor delivering into either bin. Each bin holds two carloads of material, and there is room for two cars of cement. The motor-driven mixer discharges into 7-cu. ft. Briggs steel buggies inside the house on the same level as the runways. When operating to capacity the plant turns out 100 cu. yd. per 10-hr. day.

A typical support for the slabs is 8 ft. wide by 30 ft. long. It consists of 4 x 12-in. timbers 10 ft. long laid on the ground, and over these are laid four 12 x 12-in. floorbeams, 30 ft. long, to which is nailed 2 x 8-in. tongue-and-groove flooring. These substantial molding platforms were considered essential on account of the great weight of the slabs. On these platforms the sides for the various shaped slabs are erected and then the steel is placed. To insure filling under and around all steel the large material used to make the first foot of concrete consists of broken stone from ½ to 1¼ in. in size. For the remainder of the block the stone is from ½ to 2½ in. in size.

For the columns and the end cross-girders Blaw steel forms with all inside rivets countersunk are used. Extension of the shaft form is accomplished by adding short sections at the base. Seven column forms and two cross-girder forms with capitals are provided. It is customary to wait fifteen to twenty minutes after filling the straight portions of the columns before adding the concrete for the capital. Otherwise the shrinkage during the settling period would be enough to cause a crack at the top of the shaft. To prevent sticking in the capital Mystic dulling compound is smeared on the metal, while the steel sheets for the shaft are coated with a thin paraffine oil after puttying all seams. The side forms are stripped from the slabs two days after filling with concrete. At the end of thirty days the slabs are removed to the storage yard, where special care is taken to see that they are not center-bound, experience at other plants having demonstrated that as many as 15 per cent might be broken from this cause. The slabs are permitted to set three months before using.

Cylindrical test blocks, 16 in. hgh by 8 in. in diameter, are made in galvanized-iron forms and are of the same material as each large slab. The blocks are placed on top of the slabs so as to subject them to the same tem-



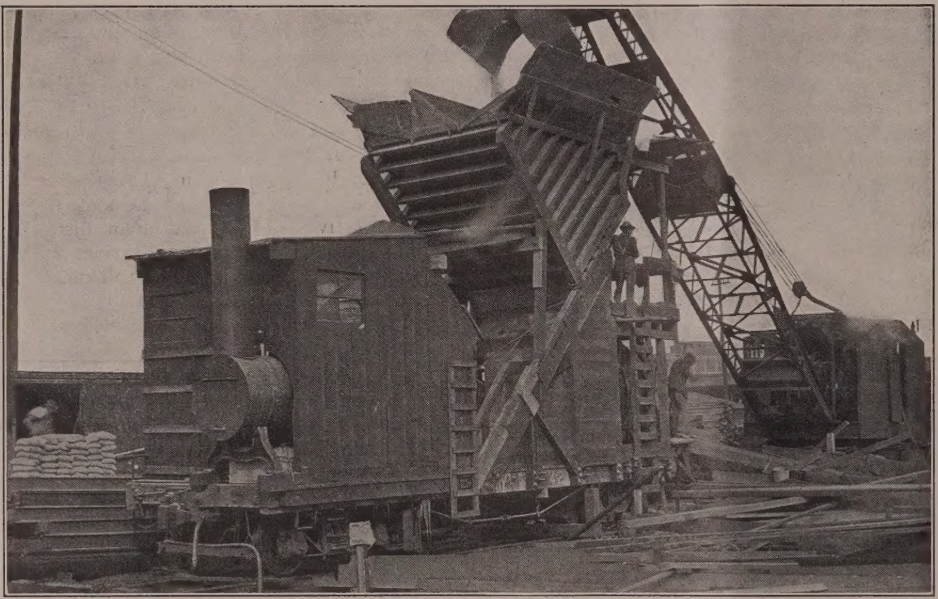
View of Slab Plant, Showing Mixer House and Casting Yard

perature and atmospheric conditions until they are to be tested. Usually they are held for ninety days, when they break under average loads of 2100 lb. per square inch.

Crusher Plant

As shown in one of the photographs, material from the crusher plant is delivered over a trestle 35 ft. above ground to storage piles, from which it is loaded by a locomotive crane into standard-gage cars. In this plant the No. 7 and No. 9 motor-driven crushers are capable of turning out about 500 cu. yd. per day. From the elevated screens the stone is delivered through hopper-bottom bins to industrial cars operated over the trestle by an endless cable. The cars are automatically tripped.

Mr. John V. Hanna is chief engineer of the Kansas City Terminal Railway Company and Mr. A. C. Everham is assistant chief engineer. Mr. G. E. Tebbetts, bridge engineer, designed and supervised the building of the subway structures, the erection of which was carried on principally by the company forces.



Portable Concrete Mixing Outfit Used on Kansas City Work

An English Channel Tunnel is again a possibility, if the efforts of the ninety members of the House of Commons who called on the Prime Minister on Aug. 5 carried conviction. The Prime Minister was urged to withdraw the veto the government had placed on the construction of the tunnel. The "Engineer" recalls the fact that the opposition to the tunnel arose after the project seemed a certainty. In 1874 the English Foreign Office approved of the idea, as did the French Government, and in 1875 the French and English Channel Tunnel companies had received concessions for the preliminary work; but within a few years the military authorities were able to interrupt the proceedings on the ground that the security of England would be threatened. At Sangatte, on the coast 5 miles south of Calais, the French company had sunk a shaft 18 ft. in diameter to a depth of 226 ft. and excavated a tunnel for a mile under the sea. The English engineers had driven a main shaft 164 ft. deep, near the Shakespeare Cliff, Dover, together with a driftway driven 6900 ft. from its foot. Since 1883, when the army authorities prevailed, the work has been at a standstill. On many occasions bills to finish the tunnel were ignored or rejected.

Highway Bridge Specifications

Requirements for Fabrication of Steel Superstructures Outlined by U. S. Office of Public Roads

A guide for local highway officials in fixing requirements to which bridge structures must conform was issued on Aug. 19 by the Office of Public Roads, of the U. S. Department of Agriculture. The pamphlet, prepared by Mr. Logan Waller Page, director, contains about twenty pages of suggested specifications, outlining good practice according to present standards.

The first page contains a convenient form for a brief description of the work, with blanks for the essential data, such as location, dimensions, and required loading, together with a list of accompanying general drawings, which, with the specifications, embody all information which will be furnished for the guidance of contractors.

The more important clauses of the specification are reprinted below.

Contractor's General Drawings.—If general drawings are submitted by a contractor as a part of his proposal, they shall include all stress sheets and such details as are necessary to express the general intent of the proposal. They shall show all general dimensions, such as length of spans from center to center of end bearings, clear width of roadway, width from center to center of trusses, depth from gage line to gage line of chords, etc. They shall indicate the assumed loads, live and dead, on which the computations are based, the sections and sectional areas of all truss and lateral members, the sizes of rivets, the thickness of gusset plates, the sizes and arrangement of floor beams and joists and their connections, and the character and quality of the materials proposed for use in various parts of the structure.

Shop Drawings.—No work shall be commenced or materials ordered until the working drawings have been approved by the engineer in writing.

Classification.—Two classes of bridges will be considered under these specifications—those which carry suburban or interurban electric cars and those which carry highway traffic only. The former will be designated as Class A and the latter as Class B bridges.

Types of Bridges.—It is recommended that the type of bridge employed be selected as follows: For spans up to 30 ft., rolled beams; for spans from 30 to 40 ft., plate girders or rolled beams; for spans from 40 to 80 ft., riveted low trusses or plate girders; for spans from 80 to 200 ft., riveted high trusses, and for spans over 200 ft., pin-connected high trusses.

Width of Roadway.—For Class A bridges the clear distance between the center line of the car track and the nearest truss shall be not less than 7 ft., and on one side the clear distance between the center line of the car track and the truss shall be at least 12 ft. The width from center to center of trusses shall in no case be less than one-eighteenth of the span.

Head Room.—The clear head room for a width of 6 ft. on each side of the center line of the bridge shall be not less than 15 ft.

Depth Ratios.—The ratio of depth to span shall be not less than the following: For rolled beams, 1/20; for plate girders, 1/12; for trusses, 1/10.

Loads

Dead Loads.—The assumed dead load shall be not less than the total weight of the completed structure. The following unit weights shall be used in computing the dead loads:

	Pounds per cu. ft.
Steel	490
Concrete	150
Brick	150
Macadam	130
Asphalt	135
Sand or earth	100
Stone	160
	Pounds per ft. b. m.
Timber—	
Creosoted	5
Oak, untreated	4½
Pine, untreated	4

Live Loads.—Class A.—For the floor and its supports and for the trusses of spans less than 50 ft. in length the live load shall be assumed as follows:

On each car track a concentrated load of 24 tons evenly divided between two axles, spaced 10 ft. center to center, with wheels spaced 5 ft. center to center on axles, shall be assumed to occupy a width of 6 ft. on each side of the center line; on the remaining floor surface, exclusive of sidewalks, a uniform load of 125 lb. per square foot and on sidewalks a uniform load of 100 lb. per square foot.

For the trusses of spans between 50 and 100 ft. in length a uniform load of 1800 lb. per linear foot for each car track (assumed to occupy a width of 12 ft.) and 100 lb. per square foot of remaining floor surface, including sidewalks, shall be assumed. For the trusses of spans greater than 100 ft. in length the live load per linear foot for each car track and per square foot of remaining floor surface may be reduced, respectively, 50 lb. and 2 lb. for each additional 10 ft. of span, provided that in no case shall these loads be reduced below 1200 lb. and 80 lb. respectively.

All Class A bridges shall be assumed as also subject to the loading specified for Class B bridges.

Class B.—For the floor and its supports and for the trusses of spans less than 50 ft. in length the live load shall be assumed as follows:

On any part of the floor surface a concentrated load of 15 tons on two axles spaced 8 ft. center to center, with wheels spaced 6 ft.

center to center on axles and two-thirds of the load on one axle, shall be assumed to occupy a space 16 ft. in the direction of traffic by 12 ft. at right angles to that direction. On the remaining floor surface, exclusive of sidewalks, a uniform load of 125 lb. per square foot, and on sidewalks a uniform load of 100 lb. per square foot, shall be assumed.

For the trusses of spans between 50 ft. and 100 ft. in length a uniformly distributed load of 100 lb. per square foot of floor surface shall be assumed. For the trusses of spans greater than 100 ft. in length the uniform load per square foot may be reduced 2 lb. for each additional 10 ft. of span, provided that in no case shall the assumed live load be less than 80 lb. per square foot of floor surface.

Distribution of Stresses Due to Concentrated Loads.—In considering the concentrated load under Class A, each wheel load shall be assumed distributed over an area of floor surface 5 ft. square. In considering the concentrated load under Class B, each wheel load shall be assumed distributed as follows: For reinforced concrete floors, protected by a wearing surface, 3 ft. in the direction of traffic by 5 ft. at right angles to that direction; for wood floors at least 3 in. thick the distribution in the direction of traffic shall be neglected in designing the joists and the distribution at right angles to the direction of traffic shall be taken as 4 ft.

Wind Loads.—The top lateral bracing in deck bridges and the bottom lateral bracing in through bridges shall be designed to resist a lateral wind load of 300 lb. per linear foot, and one-half of this shall be treated as a moving load.

The bottom lateral bracing in deck bridges and the top lateral bracing in through bridges shall be designed to resist a lateral wind load of 150 lb. per linear foot.

Temperature Stresses.—Provision shall be made for stresses due to a change in temperature of 150 deg. Fahr.

Longitudinal Forces.—For Class A bridges provision shall be made for a longitudinal force equal to 20 per cent of the weight of the heaviest electric train which could reasonably be expected to come upon the bridge.

Impact.—The maximum live-load stress in each member shall be increased to provide for impact by an amount to be determined from the formula $I = 100 S \div (L + 300)$ where I is impact or dynamic increment due to the effect of moving loads; S is computed live-load stress, and L is loaded length of bridge in feet which produces maximum live-load stress in the member under consideration.

Centrifugal Force.—When curved tracks occur on Class A bridges, the centrifugal force produced by two cars coupled together moving at 50 miles an hour shall be considered as an additional live load in designing the lateral bracing.

PROPORTIONS AND UNIT STRESSES

All members shall be so designed that the stresses coming upon them may be accurately computed, and shall be so proportioned that the sum of the maximum stresses produced by the loads herein specified shall not exceed the following amounts in pounds per square inch.

Tension.—Axial tension on net section—16,000.

Compression.—Axial compression on gross section—$16{,}000 - 70l/r$, where l is the length of the member in inches and r is the least radius of gyration of its cross section in inches.

For Class A bridges no compression member shall have an unsupported length exceeding 100 times its least radius of gyration for main members, or 120 times its least radius of gyration for laterals. For Class B bridges no compression member shall have an unsupported length exceeding 120 times its least radius of gyration for main members, or 140 times its least radius of gyration for laterals.

Bending Stresses.—Bending stresses on extreme fibers of rolled floor beams, joists, and girders, 12,500; on extreme fibers of built-up girders, 16,000; and on extreme fibers of pins, 20,000.

SHEARING	
Pins and shop-driven rivets	10,000
Field-driven rivets	7,500
Plate-girder webs (gross section)	9,000
BEARING	
Shop-driven rivets	20,000
Pins and field-driven rivets	15,000
Wall plates on concrete masonry (1:2½:5)	500
Wall plates on stone masonry (ashlar)	500
Wall plates on stone masonry (rubble)	400
Expansion rollers (per lineal inch)	d500

d is the diameter of the roller in inches.

Alternate Stresses.—Members subject to alternate tensile and compressive stresses shall be proportioned to resist each kind of stress, and each stress shall be considered as increased by an amount equal to eight-tenths of the smaller stress in determining the sectional area. The connections shall be proportioned for the arithmetical sum of the stresses.

Combined Stresses.—Members subject to a combination of direct and bending stresses shall be designed so that the greatest unit fiber stress shall not exceed the allowable unit stress for the member.

Counters.—Wherever the live and dead load stresses are opposite in character, only two-thirds of the dead-load stress shall be considered effective in counteracting the live-load stress.

For Class A bridges counters shall be so provided and proportioned that an increase of 25 per cent in the specified live load would not increase the unit stress in any member more than 25 per cent.

Proportioning Plate Girders.—The flanges of plate girders shall be assumed to take all the bending moment, and the web shall be assumed to take all the shear. The compression and tension flanges shall have the same gross section.

THE FLOOR SYSTEM

Floorbeams.—All floorbeams shall be rolled or riveted steel girders and shall be rigidly connected to the trusses or side girders. They shall, when practicable, be placed at right angles to the direction of traffic.

Joists.—All joists shall be rolled or riveted steel girders and shall be rigidly fastened to the floorbeams. When wood floors are used, the joists shall be riveted to the webs of floor beams by means of connection angles. The spacing of joists center to center shall be not greater than 3 ft.

Wood Floors.—Wood floors shall be constructed of first-quality timber of the kind specified by the engineer in writing or indicated on his drawings. For oak floors the minimum thickness of plank used shall be 2½ in., and for pine the minimum thickness shall be 3 in. In no case shall the thickness of the floor plank be less than one-twelfth of the distance, center to center, between joists. All plank shall be laid with the heart side down at right angles to the direction of traffic. Spaces of approximately ¼ in. shall be left between adjacent planks.

Wood floors shall be provided with a wheel guard on each side of the roadway. Wheel guards shall be constructed of timbers having a cross-section of not less than 6 x 4 in., spliced with 6-in. lap joints, and shall be securely bolted to the joists at intervals not to exceed 5 ft.

DETAILS OF DESIGN AND CONSTRUCTION

Camber.—Truss spans shall be given a camber by making the horizontal projection of the top chord longer than the bottom chord by 3/16 in. for each 10 ft. of span.

The neutral axes of connecting members shall meet in a point.

Rivets and Rivet Spacing.—Diameter.—Rivets shall be either ⅞ in., ¾ in., or ⅝ in. in diameter, except when used in minor parts.

Pitch.—The maximum pitch in the line of stress shall not exceed 6 in., or 16 times the thickness of the thinnest outside plate. The minimum pitch shall not be less than 3 in. for ⅞-in. rivets, 2½ in. for ¾-in. rivets, and 2 in. for ⅝-in. rivets. For plate girders the rivet spacing in the vertical legs of the flange angles shall be determined from the formula, $p = rh/s$, where p is the pitch in inches, r the permissible stress in one rivet in pounds, h the distance between lines of rivets in inches, and s the maximum shear in pounds at the section under consideration. In no case, however, shall the pitch exceed 4 in.

Edge Distance.—The minimum distances from center of rivet holes to the nearest edge shall be not less than 1½ in., 1¼ in. and 1 in. for ⅞-in. rivets, ¾-in. rivets, and ⅝-in. rivets respectively. The maximum distance from any edge to the center of rivet holes shall not exceed eight times the thickness of the thinnest outside plate or 6 in.

Rivets in Flanges.—Unless otherwise specified on the engineer's drawings or by the engineer in writing, ⅝-in. rivets shall be used for all flanges less than 2½ in. wide, ¾-in. rivets for flanges between 2½ and 3½ in., and ⅞-in. rivets for all flanges over 3½ in. wide.

Grip of Rivets.—The grip of rivets shall, in general, be not greater than 4 diameters. When it is necessary to make the grip greater than 4 diameters, the allowable unit shearing strength shall be decreased 1 per cent for each 1/16 in. of additional grip.

Pin Connections.—All pins shall be sufficiently long to furnish full bearing upon the turned body of the pin for all connecting parts. All pins shall be secured by chambered nuts and the screw ends shall be sufficiently long to admit of burring the threads after the nuts are set.

No pin shall have a diameter less than three-fourths the width of the widest eyebar attached to it.

Riveted tension members having pin connections shall have a cross-sectional area through each pinhole 25 per cent in excess of the net sectional area of the members. The sectional area of the metal between the pinhole and the end of the member shall not be less than 75 per cent of the sectional area through the pinhole.

Batten Plates and Lattice Bars.—Batten plates shall have a thickness of not less than ¼ in. nor one forty-fifth the distance between the lines of rivets connecting them to the flanges. They shall have a width parallel to the axis of the member not less than the maximum width of the member.

Lattice bars shall have a thickness not less than 5/16 in. nor less than one forty-fifth their unsupported length. They shall be inclined to the axis of the member at an angle not less than 60 deg. for single latticing nor less than 45 deg. for double latticing. Double latticing shall be riveted at intersections.

The width of lattice bars shall not be less than 2 in. nor less than one-sixth the width of the member of which they form a part.

Splice Plates.—Where splice plates are separated from the parts which they connect by intervening plates or fillers, the number of rivets on each side of the joint shall be increased by 33⅓ per cent of the number theoretically required for each intervening plate.

Eyebars.—The thickness of eyebars shall not be less than ⅝ in. nor less than one-seventh the width of the bar. Heads of eyebars shall be formed by upsetting and forging, and never by welding. The heads shall be so proportioned as to develop the full strength.

Eyebars shall be perfectly straight at the time they are bored, and all bars which work together as one member shall be piled, clamped together, and bored in one operation.

The eyebars composing a member shall be so arranged that their surfaces are not in contact. The inclination of individual eyebars to the axis of the member which they compose shall not be greater than 1 in. in 16 ft.

Rods.—No rod shall be used which has a cross sectional area less than ¾ sq. in.

All rods having screw ends shall be upset previous to threading, so that the net sectional area at the root of the threads shall be greater by at least 17 per cent than the net sectional area of the rod.

Compression Members.—Compression members shall be so designed that any part or segment of a member will be proportionately as strong as the member taken as a whole.

No web shall have a thickness less than one-thirtieth the distance between the lines of rivets connecting it to the flanges, and no cover plate shall have a thickness less than one-fortieth the distance between rivet lines.

Flanges of built members which have no cover plates shall have a thickness not less than one-twelfth the width of the outstanding leg.

Lateral System.—All lateral and portal bracing shall be made of shapes capable of resisting both compression and tension, and shall have riveted connections to the chords.

Laterals shall be as nearly in the plane of the axes of the chords as practicable. When eccentricity is unavoidable, however, provision shall be made for the maximum bending stresses which would be produced in the connections with the member fully loaded.

Portals for through bridges shall be as deep as the specified head room and depth of truss will permit. They shall consist of top and bottom struts and stiff intermediate bracing. All portals shall be provided with curved knee or corner braces.

Intermediate top struts in through bridges shall have a depth not less than that of the top chord, and, if the engineer so requires, they shall be provided with curved knee or corner braces.

End struts shall be provided at the ends of all bottom chords.

Sway Bracing.—All deck bridges shall be provided at each panel point with sway bracing made of shapes capable of resisting both tension and compression. The sway bracing shall extend the full depth of the trusses, and at the end of the trusses ample provision shall be made for transferring all wind loads to the piers or abutments.

MATERIALS

Chemical Composition.—The steel shall be made by the open-hearth process and the steel shall be uniform in character and shall conform to the following requirements as to chemical composition:

Elements considered	Structural steel	Rivet steel	Steel castings
Phosphorus, maximum per cent:			
Acid	0.06	0.04	0.08
Basic	.04	.04	.05
Sulphur, maximum per cent	.05	.04	.05

Physical Properties and Tests.—The tensile strength, elastic limit, and ductility shall be determined by testing samples cut from the finished material after rolling. The samples shall be not less than 12 in. long and shall have a uniform sectional area of not less than ½ sq. in.

Structural Steel.—Structural steel shall have an ultimate strength of not less than 60,000 lb. and not more than 70,000 lb. per square inch, an elastic limit of not less than one-half the ultimate strength, and a minimum elongation of 20 per cent in 8 in. For eyebar material not over 20 per cent shall show a tensile strength of less than 62,000 lb. or more than 68,000 lb. per square inch. Steel for pins may have a minimum elongation of 15 per cent. All structural steel shall withstand bending cold without cracking through 180 deg. around a pin the diameter of which is one and one-half times the thickness of the specimen. Full size material for eyebars shall withstand bending cold without cracking through 180 deg. around a pin the diameter of which is equal to the thickness of the material.

Pins over 7 in. in diameter shall be forged. Blooms for pins shall have at least three times the sectional area of the finished pin.

Rivet Steel.—Rivet steel shall have an ultimate strength of not less than 48,000 lb. and not more than 58,000 lb. per square inch, an elastic limit of not less than one-half the ultimate strength, and an elongation of not less than 26 per cent in 8 in.

Copies of the specifications may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents per copy.

Blount and Hayden Mountain Tunnels

Comparison of Materials and Conditions Encountered and of the Methods Employed in Driving Two Double-Track Bores

In an earlier article on the Louisville & Nashville Railroad work in Alabama mention was made of two tunnels on the new line under construction between Blount Springs and New Castle. These tunnels, which are to be about 1000 and 2100 ft. long respectively, are only 2 miles apart and are on the same contract. The shorter and northerly one, called the Blount tunnel, is through hard, homogeneous limestone. It is being driven by means of a bottom heading, and it is not decided whether it will have to be lined. The longer one, known as the Hayden Mountain tunnel, is through a constantly changing material, hard in places and at others so soft as to afford little support for the bracing. It is being driven with a top heading, and will have to be lined.

BLOUNT TUNNEL

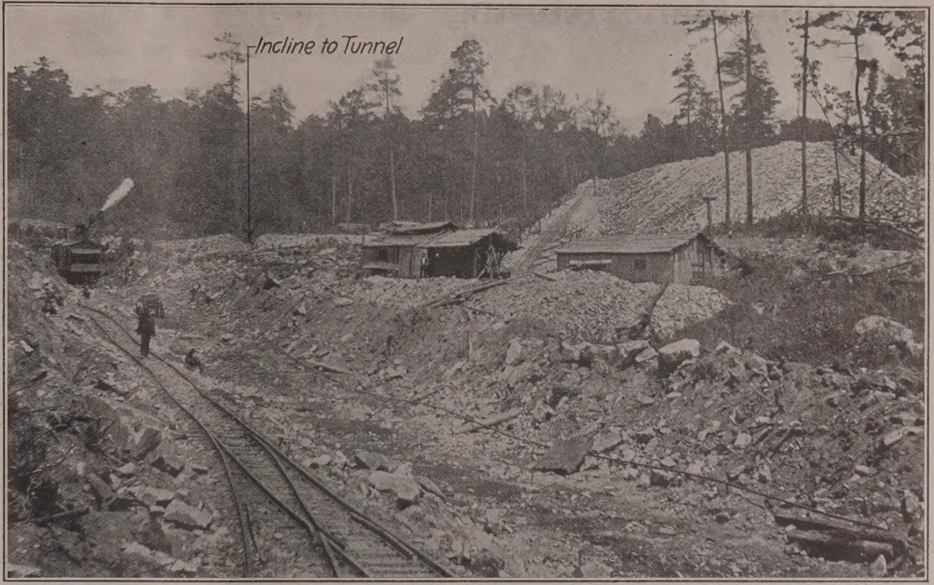
One of the illustrations shows the heading at grade of the Blount tunnel as seen from the cut at the north end. There are heavy approach cuts at each end, but by turning in from the side it was possible to get at the north portal without removing the entire cut. The heading was driven through to a height of 7 ft. above subgrade and in general the full width of the double-track tunnel, with enough extra width to permit lining if it should prove necessary. The heading was driven through in 130 working days, employing two shifts.

While this heading was being driven the south-approach cut was being opened up. A narrow-gage track was then laid through the tunnel. The top section is now being removed by the following method: Beginning at the south portal, holes for blasting are driven upward into the solid rock at an angle of about 30 deg. with the vertical, the angle being toward the south portal. From side to side of the tunnel there are six of these holes in each row, and the rows are about 7 ft. apart. All of the holes in a row are charged and set off simultaneously, the loosened rock falling to the floor of the tunnel, where it is picked up by a Marion 41 shovel operated by compressed air, loaded on side-dump cars on the narrow-gage track and hauled out by a dinkey to be dumped into permanent embankment beyond the cut. By keeping the shovel the right dis-

Bottom Heading and Rock Formation at North Portal to Blount Tunnel

tance behind the blasting the top of the loosened pile is kept just high enough to allow laborers on top of it to scale off the loose rock from the roof of the enlarged tunnel.

The blast holes are driven with Ingersoll drills operated by compressed air. The longest holes are 22 ft. deep, and as each drill must be replaced by a longer one when it has advanced 2 ft., eleven lengths of drill are required for the deepest holes. As the depth of the bottom heading is as already stated only about 7 ft., the longer drills can be got in and out of the holes only by springing them and working them a short distance at a time. The drills are 1 in. in diameter, and are necessarily of a high grade of steel to withstand at the same time the springing and the hard rock encountered. The cutting edges do not last long; but in order to keep the numerous drills in service a Leyner drill sharpener has been set up in a shop near the north portal. With it a previously heated drill can be sharpened in a few seconds, and it is kept ready for service, being operated by compressed air. The Leyner machine was furnished by the Ingersoll-Rand Company, of New York City.



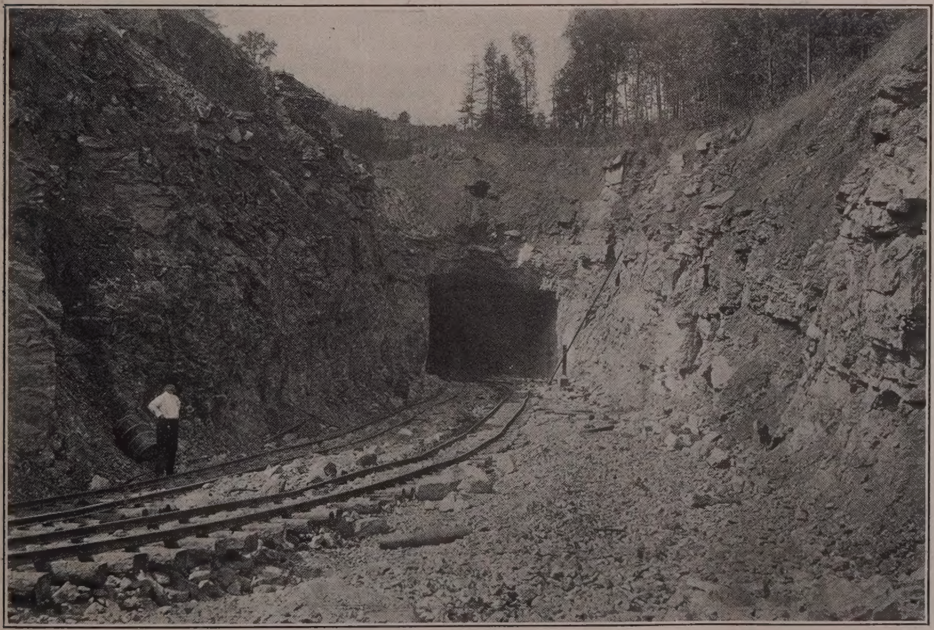
Contractor's Operations at South End of Hayden Mountain Tunnel
Note switchback and waste trestle in background

HAYDEN MOUNTAIN TUNNEL

The Hayden Mountain tunnel is being driven from both ends with top headings. The north-approach cut is small and the portal was easily reached. That at the south end, however, is ¾ mile long and involves more than 200,000 cu. yd. In order to get at the portal, therefore, an incline at about 30 deg. with the horizontal was driven. Up to May 1 the south heading had advanced about 1000 ft. and the north one 400 ft., leaving 700 ft. between the two.

The material thus far encountered appears to change in character about every 200 ft. In some places it is hard and solid and requires no temporary bracing; at other points it is so soft that difficulty is experienced in getting adequate support for the bracing. Water drips abundantly from the roof of the heading at some points, while at others it is entirely dry. One of the worst spots encountered was at the north portal. Here the material is soft and wet, and that above gave indications of a desire to slide longitudinally into the cut. The bottom section at the portal was, therefore excavated and the portal was built at once about 50 ft. farther out than was originally intended. In order to get sufficient bearing for the concrete lining in the soft material, footings 6 ft. wide were laid. The lining has been placed a short distance in, and it is believed that the tunnel and cut are now sufficiently protected against any slide.

At this end the material is being hauled out in cars by mules and dumped off the end of the fill near by. At the other or south end, however, the situation is much more complex. The line as located from the tunnel south follows a narrow and winding ravine, and the subgrade will, when the cut is finished, be from 35 to 40 ft. below the original bottom of the ravine for a distance of ½ mile or more. Thus far the cut has been taken out to about half its final depth only, the spoil being used up in the embankments beyond, the quantities of which exceed those of the short cuts between them. Most of the remainder of the material will have to be hauled 3 miles to a 250,000-cu. yd. embankment. This embankment, which will be 3000 ft. long and up to 52 ft. high, is notable in that it will be along a ridge and will require absolutely no opening for drainage. The approach cut, which is hard sandstone, is being taken out with a Marion 60 steam shovel, and hauled away by narrow-gage dinkeys in eight-wheeled 8-yd. side dump cars of the Oliver and Western makes.



Full Size of Blount Tunnel as Seen from the South Approach

In order to get started on the south end of the tunnel before the cut could be opened the incline previously mentioned was opened up and a narrow-gage track laid on it. The track was carried on up the hillside by means of a double switchback. Loaded cars are hauled out of the tunnel and up the two inclines by cables operated by a stationary engine, and the material is wasted off a trestle at the high level, the empty cars returning by gravity.

COMPRESSOR PLANT

The compressor plant for both tunnels is located along the present line of the railroad at Blount Springs, about 1 mile from Blount tunnel. The air is piped from the plant to the Blount tunnel and from there to the Hayden Mountain tunnel, and some distance beyond (4 miles in all), supplying the drills in the tunnels and the cuts, the drill sharpener, and the Marion 41 shovel in the Blount tunnel. From the compressor plant to the first tunnel an 8-in. cast-iron pipe is used; from the first to the second, a 6-in., and beyond that a 4-in. The pipe is laid on or near the surface of the ground, and several expansion joints have been placed in the long straight stretches. Such a joint is made by an offset in the pipe line, the gap being closed by an elbow turned upward at each of the unconnected ends of the main pipe, and a short straight length with an inverted elbow at each end engaging the first two elbows. The short length is above the main pipe line and about at right angles thereto, changing its direction as the main line pushes together or pulls apart. The arrangement of plant and pipe line has worked very successfully, with little loss of pressure for the 4 miles.

All of this work is being done by Messrs. Thrasher & Gunter, contractors, of Knoxville, Tenn., under the general supervision of Mr. John Howe Peyton, chief engineer of construction of the Louisville & Nashville Railroad, and under the more immediate direction of Mr. T. O. Harrison, engineer of construction of the South & North Alabama Railroad, which is the corporate name of the subsidiary company handling the work. Mr. Asher Dole is resident engineer on the work.

Duff Manufacturing Company's Plant

Wide Steel and Glass One-Story Shop, with Crane and Telpher Systems, for Manufacturing Hydraulic and Screw Lifting Jacks

The plant of the Duff Manufacturing Company is located in a 5-acre lot on Preble Avenue, Northside, Pittsburgh, where the company just put in operation a 125 x 550-ft. main shop built and equipped for the manufacture of the large variety of Barrett ratchet jacks and screw and hydraulic lifting jacks of capacities from 1200 lb. to 500 tons. The shop is designed for machining and assembling pieces of light or medium weight, and has a large number of electrically driven machine tools designed for rapid and accurate work. The wide floor space is illuminated by an unusually large proportion of wall lights. The obstruction of the floor by interior columns is reduced by supporting alternate roof trusses on longitudinal girders. Lighting and ventilation are improved by the exclusive use of wire screens for partitions. Materials and products are handled for unloading, fabrication and shipment by a girder crane traveling the whole length of the building and by a system of telpher hoists running across the building transverse to it in every panel between columns. Provisions for comfort and sanitation are secured by a hot-air heating system and an ample ventilating plant, together with a lavatory and locker rooms.

Structural Features

Transverse bents 25 ft. apart on centers divide the steel framework of the building into twenty-two panels. Except where one corner is cut off, diminishing the width of the building at that end, the main bents are duplicates, with four transverse roof trusses and five columns in each, dividing the floor into one 35-ft. and three 30-ft. aisles. In the 30-ft. side aisles the clearance of the roof trusses above the floor is 18 ft. and in the 35-ft. center aisle it is nearly 24 ft., providing additional headway there for the girder crane and making a monitor-like construction with two full-length clere-story windows, 6 ft. 4 in. high.

The roof trusses are spaced 12½ ft. apart, those intermediate between the main bents being supported on wall columns and on three intermediate lines of longitudinal latticed girders 6 ft. deep over all. All columns are 8-in. 34.5-lb. H-beams. All bottom chords except those of the trusses in the 35-ft. panels are made of pairs of channels back to back; all other members of the riveted trusses are made of pairs of angles.

The walls are of brick for about 3 ft. above the floor and from the bottom to the top chords of the longitudinal trusses. The intervening space, which is about 14½ ft. high, is entirely filled with Lupton steel wall sash and with Pond continuous steel monitor sash, containing large double ventilators and pivoted sections controlled by the Pond operating device so that a large proportion of the area can be opened in hot weather.

The floors of the warehouse, lavatories, tool department, boiler room and fan room are of concrete; those of the heat-treating department and forge rooms are of hard paving blocks, and that of the main machine shop is of asphalt limestone blocks. The reinforced-concrete roof slabs are pitched 1:24 and are carried on longitudinal channel purlins 5 or 6 ft. apart.

Clerestory and Side-Wall Illumination and Wire-Mesh Partitions

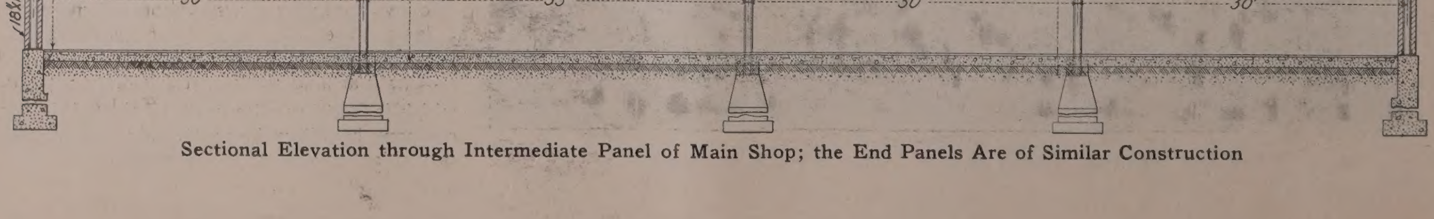
Crane and Telpher Systems

The entire building is commanded by a system of transverse telpher tracks. These tracks are 25 ft. apart longitudinally and extend across the 30-ft. aisles, being suspended from the lower chords of the intermediate roof trusses. They are equipped with electric hoists of 5-ton capacity, with trolleys running on 15-in. I-beams, which in all cases project 14½ in. beyond the faces of the columns in the 35-ft. aisle to connect with a corresponding beam suspended from the girder crane, thus enabling the hoist to be carried across the wide aisle or transferred longitudinally to any other track in the building. In some places the 15-in. I-beams are extended through the side walls of the building to provide for special service as required. The crane runway is extended through the main doors and into the unloading and shipping yards at both ends of the building so that it can command the tracks of the Baltimore & Ohio and of the Pennsylvania Railroads.

Power Plant and Equipment

All machine tools are operated separately or in groups by electric motors using a three-phase, 440-volt current. The large machine tools are located in the 35-ft. aisle, where they are directly served by the traveling crane. The smaller tools are installed in the side aisles, on the column lines under the main trusses, the spaces between them being served by the hoists on the intermediate trusses. All shafting runs on roller bearings, and the oil supply for all machines is through gravity from a central tank. The return oil passes through strainers to a large tank, from which it is electrically pumped into gravity tanks and circulated continuously through the distributing system.

The rough and finished stock rooms are completely equipped with steel bins of 2000 lb. capacity furnished by the Berger Manufacturing Company. Each bin is numbered and labeled with the identifying mark and has a card giving its capacity and the minimum



Sectional Elevation through Intermediate Panel of Main Shop; the End Panels Are of Similar Construction amount to be maintained there, together with a tally sheet on which the number of pieces received and removed are recorded. Drills and other tools are standardized and all are stored in a central supply room, where they are inspected, ground, maintained in good condition, and checked in and out. The foreman's office is centrally located and has metal and glass walls through which an unobstructed view of the entire shop is afforded. Patterns are stored in a fireproof room in the main story over a 150-ton testing machine installed in a 25 x 50-ft. pit 15 ft. deep. The machine provides for working tests of jacks of any capacity.

Heating and Lighting

Two 100-hp low-pressure steam boilers heat fresh air, which is forced through ducts under the floor near both outside walls by a Sturtevant fan and discharged through cast-iron double-throw outlets at wall columns about 45 ft. apart.

The 35-ft. aisle is equipped with Tungsten lamps in Abolite reflectors 23 ft. above the floor, 22½ ft. apart transversely and 10 ft. apart longitudinally. In each panel at each side there are three lights 18 ft. above the floor. On each side of each main roof truss there is a circuit with boxes for three drops providing for lights for the individual machines, although these lights have not yet been found necessary and have not been installed. A special system of watchman's lights is installed on the center line of the building and is operated only when the watchman is going his rounds. The watchman's stations are also fire-alarm boxes and his reports are registered at the main office of the American District Telegraph Company, so that he is under constant supervision and a failure to report at the proper station would at once be investigated.

Workmen's Accommodations

The lavatory contains more than two hundred and fifty steel lockers for the employees and is equipped with white enameled washbowls. It is under control of the day watchman and is kept closed during working hours to prevent loss of time. Fire hose and sanitary drinking fountains are located at six points in the building. The drinking water, which comes from two deep wells, is filtered, sterilized and cooled at a central point and piped to the six fountains.

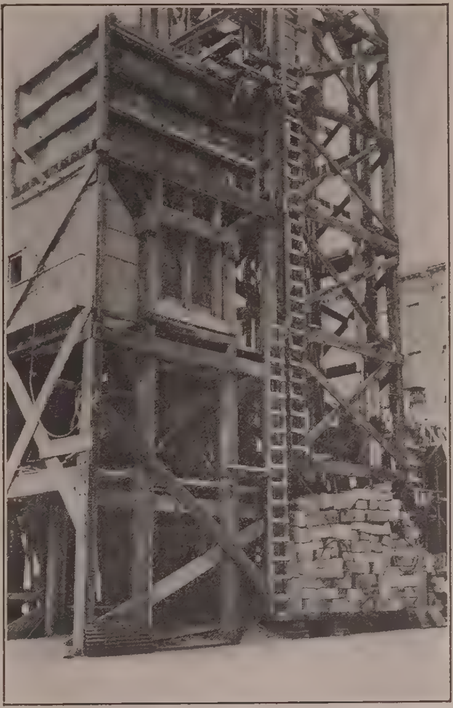
Working hours are indicated by the time-clock, which automatically rings the gong for work to commence and finish. To reduce the danger of accidents all switchboxes, motor-starting boxes, gears, pinions and wheels are inclosed with wire screen, all power and lighting wires are run in conduits, and at every point of danger there is conspicuously displayed the large solid red circle, adopted by the National Association of Manufacturers to warn employees who may not be able to read the notices.

The building was designed, equipped and arranged under the direction of the Duff Manufacturing Company. The W. G. Wilkins Company, of Pittsburgh, was the engineer and Mr. J. F. Kuntz was the architect. James Stewart & Company, of New York and Pittsburgh, were the general contractors, and the structural steel work was fabricated by the Jones & Laughlin Steel Company.

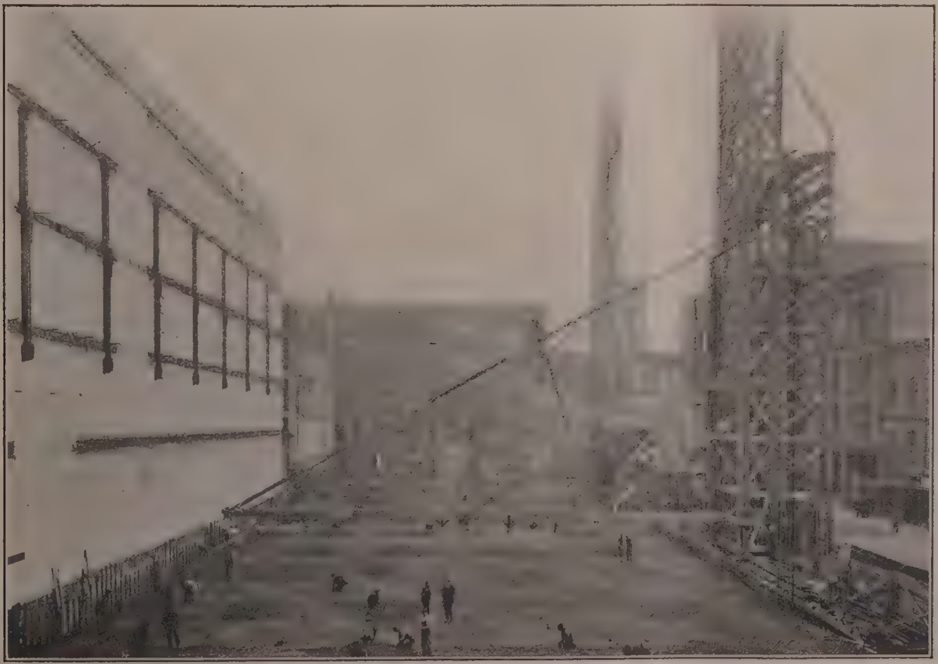
Self-Supporting Concrete Towers and Novel Chute Supports

Two self-supporting concrete towers with 90-ft. booms are being used to distribute mixed concrete for an eight-story basement and sub-basement reinforced-concrete building now being erected for the Gordon & Ferguson Company, at Sibley and Fourth Streets, St. Paul, Minn. The building is 288 x 100 ft. in plan and requires 15,000 cu. yd. of concrete. Havermeyer bars are used for the reinforcing, which is of the mushroom type. As the site is in a crowded business section where it was impossible to obtain permission from adjoining property owners to attach guy wires to their buildings, the towers had to be built with sufficient stability to stand alone.

Next to the building an ordinary tower was erected, except that it was made of heavier timber than usual. In the rear an auxiliary tower, 10 x 16 ft. in plan, was built to a height of about 70 ft. The main tower will, at the time the building is completed, reach about 175 ft. above the pavement. To counterbalance the weight of the boom and three chutes, which are suspended by cables, the rear tower is weighted with stone, as its own weight was not sufficient to serve as an anchorage. Within the rear shaft is an elevator skip on which loaded wagons are driven and materials dumped. After the team is driven off the material is hoisted and automatically dumped into elevated bins located at one side of the auxiliary tower.



Counterweight at Rear of Tower



Self-Supporting Concrete Towers and Novel Chute Supports in a Crowded Street

A rectangular timber frame, which slides up and down on the two front timbers of the main tower as guides, carries the boom and chutes on a pivoted connection. To raise this frame a block and tackle is fastened to an overhanging timber extending from the main tower, a lead running to a nigger head on the hoisting engine. The circle of these booms is sufficient with the small pivoted chutes at the ends of the main chutes to cover the whole area.

In the main shaft the Lakewood hopper is carried in a sling and raised or lowered to a point opposite any one of the three chutes. The two 1-yd. mixers, a Lakewood and an Austin cube, are located directly under the material bins at the level of the second bent of the main tower, so that it is unnecessary for the elevator buckets to be lowered quite to the street level.

Butler Brothers, of St. Paul, are the general contractors and Mr. C. H. Johnston is the architect.

Temporary Wing Dams made of refuse piling and cheap lumber will be constructed to check the erosion taking place on the shore of Limon Bay, immediately to the west of the west channel of the Panama Canal. A considerable section of the shore at this point, according to the "Canal Record," has been worn away, and erosion will probably continue unless preventive measures are taken. As it is not definitely known whether the adopted method will check the wave action sufficiently to warrant the construction of permanent dams, these temporary structures, expected to hold together for at least a year, will now be erected at a cost of about $2000. During that period opportunity will be afforded for studying their effect on the shore line, to determine whether permanent structures will be suited.

Formulæ for Weights of Cast Tees and Crosses

In connection with the cost estimating system for the San Francisco auxiliary water supply for fire protection, which was described in the Engineering Record of July 26, 1913, page 107, the computation of the weights of cast-iron and steel tees and crosses was a troublesome problem.

No theoretically exact method could be developed for computing the volumes of such mathematically complex solids as these, but after considerable study the formulæ given below were evolved. That they are sufficiently accurate for all practical purposes is shown by the fact that the actual weights of 800 tons of tees and crosses were found to be within 2.3 per cent of the computed weighs.

The formulæ may appear cumbersome, but by using them the computer will avoid the clumsy, tedious and less accurate graphical methods which he must work out for himself, and which seem to be the only alternative.

No attempt should be made to obtain greater precision than the slide rule will give.

Two cases present themselves, requiring different methods of treatment.

Case 1.—All Outlets Equal in Diameter

(*Method Developed by A. J. Bowie, Jr., Formerly Assistant City Engineer*)

Referring to Fig. 3, the volume of the portion *ABCDE* is one-fourth of the volume of the entire cross, or one-half that of the branch side of a tee (omitting bells). Divide this into two sections, *ABHFG* and *GFHCDE*.

The volume of the ring $ABHG = \pi k (R^2 - r^2)$.

The volume of the whole figure *GHF*, neglecting for the present the taper of thickness of the casting, as found by integration $= 1.808 R^3$.

From this must be deducted *KLF*, which similarly $= 1.808 r^3$, and the cylinder $KLMN = \pi r^2 t$. The allowance to be added for taper of thickness is found by integration to be $0.71 R^2 (u - t)$, where u is the thickness of metal at the point F (estimated mentally).

Summing up, the volume of metal in the section *ABHFG* is

$$V_1 = \pi k (R^2 - r^2) + 1.808 (R^3 - r^3) - \pi r^2 t + 0.71 R^2 (u - t) \qquad (1)$$

Fig. 4 shows a cross-section through *DEGFHC* on the line *OPQ*. The boundaries of the cross-section of the metal approximate closely to ellipses, and may be considered ellipses for this computation.

The area between the two ellipses =

$$(p + z)(r + y) - pr = (rz + py + yz)$$

where r = same as in Fig. 3, and p, y, and z are readily computed.

Take sections thus on the lines *GF* and *ED* and two intermediate sections, cutting *DEGFHC* into three layers of equal thickness, let d = the thickness, or distance between sections, and x_1, x_2, etc. = the value of $(rz + py + yz)$ for the respective sections; then the volume of metal in *DEGFHC* is

$$V_2 = \pi d [(x_1 + x_4)/2 + x_2 + x_3] \qquad (2)$$

If the casting under consideration is a tee, the volume of the plain side (opposite to the branch) is

$$V_3 = \pi c (2r + t) t + \pi (s - t)(c - k) \times [r + (2t + s)/3] \qquad (3)$$

Formulæ for Weights of Castings

Let w = weight per cubic inch of metal, (0.2604 lb. for cast iron, 0.2836 lb. for cast steel) and V_1, V_2 and V_3 = volume in cubic inches obtained by means of equations (1), (2) and (3) respectively. All dimensions are in inches.

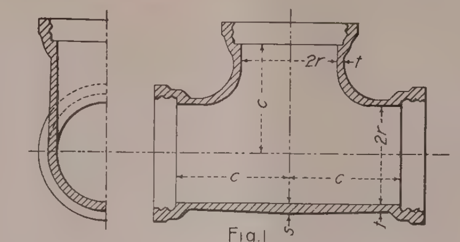


Fig. 1

Weight of Cross

$W_c = 4w (V_1 + V_2) +$ weight of four bells.

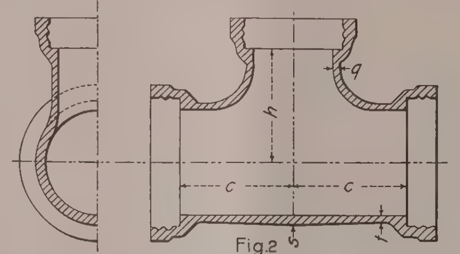


Fig. 2

Weight of Tee

$W_t = w (2V_1 + V_2 + V_3) +$ weight of three bells.

Case 2.—Run and Branch of Unequal Diameters

(*Method Developed by Leslie W. Stocker, Assistant City Engineer*)

It may be assumed in this case, without appreciable error, that the volume of metal in the casting, with fillet as shown in Fig. 2, is equal to the volume that it would contain if formed by two intersecting cylinders without any fillet, as shown in Fig. 5. This may be proved by taking sections in various planes drawn to scale and measuring them with a planimeter. The intersection has been considered sharp in working out the formulæ given below. The computation is based on surfaces taken at the center of the thickness of the metal.

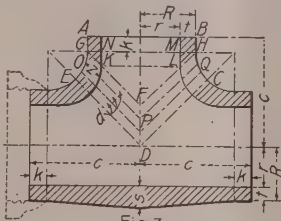


Fig. 3

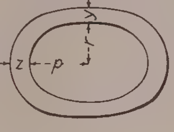


Fig 4

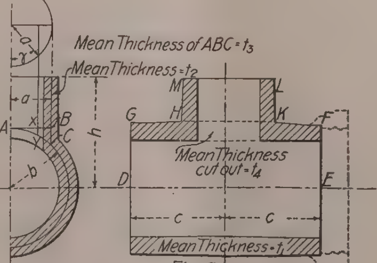


Fig. 5

Consider the upper half of the casting as shown in Fig. 5 to be composed of a half cylinder *DEFG*, a cylinder *HKLM*, and four triangular pieces, of which *ABC* is one.

The opening in the run is approximately an ellipse, of which the semi-minor axis $= a$; semi-major axis $= 0.01745\, b$ times angle *AOC* in degrees. [Angle $AOC = \sin^{-1}(a/b)$]. Area $= 0.0548\ ab$ times angle *AOC* in degrees $(0.01745 \pi = 0.0548)$.

In the surface *ABC* the area of an element $XY = (b - \sqrt{b^2 - a^2 \sin^2 \gamma})\, a d\gamma$.

$$\text{Area } ABC = \int_0^{\frac{\pi}{2}} (b - \sqrt{b^2 - a^2 \sin^2 \gamma})\, a d\gamma = ab (\pi/2 - E)$$

The value of the elliptic integral E corresponding to the angle $AOC = \sin^1 a/$ is found from the table given below.

Formulæ for Weights of Castings

Let w = weight per cubic inch of metal.
a = mean radius of metal in branch.
b = mean radius of metal in run.
t_1, t_2, etc. = average thickness of metal in the various parts of the casting (estimated mentally from thicknesses used in design).
E = quantity taken from following table:

$\sin^{-1}(a/b)$	E	$\sin^{-1}(a/b)$	E	$\sin^{-1}(a/b)$	E
20°	1.524	45°	1.351	70°	1.118
25°	1.498	50°	1.305	75°	1.076
30°	1.468	55°	1.259	80°	1.040
35°	1.422	60°	1.211	85°	1.013
40°	1.393	65°	1.164	90°	1.000

Weight of Cross

$$W_c = w[4 \pi bct_1 + 4 \pi a (h - b) t_2 + 8ab (\pi/2 - E) t_3 - 0.1096\, abt_4 \sin^{-1}(a/b) \text{ (in degrees)}] + \text{weight of four bells.}$$

Weight of Tee

$$W_t = w [4 \pi bct_1 + 2 \pi a (h - b) t_2 + 4ab (\pi/2 - E) t_3 - 0.0548 abt_4 \sin^{-1}(a/b) \text{ (in degrees)}] + \text{weight of three bells.}$$

Fuel Saving at Madison Pumping Station

The Board of Water Commissioners of Madison, Wis., inagurated during the year 1912 a fuel-buying system that, according to their annual report, saved $1290 on the yearly coal bill of $10,000. Previous to July, 1912, Pocahontas coal was used entirely. Its cost was $4.35 per ton delivered at the pumping station, but when the bids for the year's supply were received the price had advanced to $4.80 per ton. New Kentucky screenings were quoted at $3.65 per ton on specifications being based on heat value generated and the ash content.

During the first seven months of the year, when Pocahontas coal was burned, it required 2,633,700 lb. of coal to pump 406,346,650 gal. against a total head of 230 ft. and 268,967,000 gal. against a total head of 6 ft. The duty per 100 lb. of coal consumed was 35,150,000 ft.-lbs. per 100 lb. of coal consumed.

If Pocahontas coal had been used during the last five months of the year the same duty obtained as during the first seven months, the cost of fuel per 1,000,000 ft. lb. duty would have been 0.683 cent. During the last five months of the year, when New Kentucky screenings were burned, it required 2,380,900 lb. of coal to pump 308,590,450 gal. against a total head of 230 ft. and 256,222,000 gal. against a total head of 65 ft. The duty per 100 lb. of coal consumed was 30,670,000 ft. lb. per 100 lb. of coal consumed.

The cost of coal per 1,000,000 ft. lb. duty was 0.595 cent. The difference in the cost of fuel per 1,000,000 ft. lb. duty was 0.088 cent, or a saving in favor of the New Kentucky screenings over the Pocahontas coal of 12.9 per cent.

Machinery Hall, Panama-Pacific Exposition

One of the Largest Timber Structures Ever Erected—It Has a Floor Area of 8 Acres and Must Be Completed in 240 Days

Machinery Hall, the building with a floor area of 8 acres, which is being erected for the Panama-Pacific Exposition in San Francisco, ranks among the largest timber structures ever designed. It has a length of 967 ft., a width of 367 ft., an extreme height of 135 ft., and is designed to stand up during an earthquake such as occurred in San Francisco seven years ago. In order that the great hall might be ready in ample time for the Pacific Coast's celebration in 1915 the contract required that construction be completed in two hundred and forty calendar days. This stipulation has made it necessary to rush the work of erection, and during the week ended June 14, for example, an amount of timber aggregating 600,000 ft., b. m., was placed in the building. In four hours a record of 55,000 ft., b. m., was made recently.

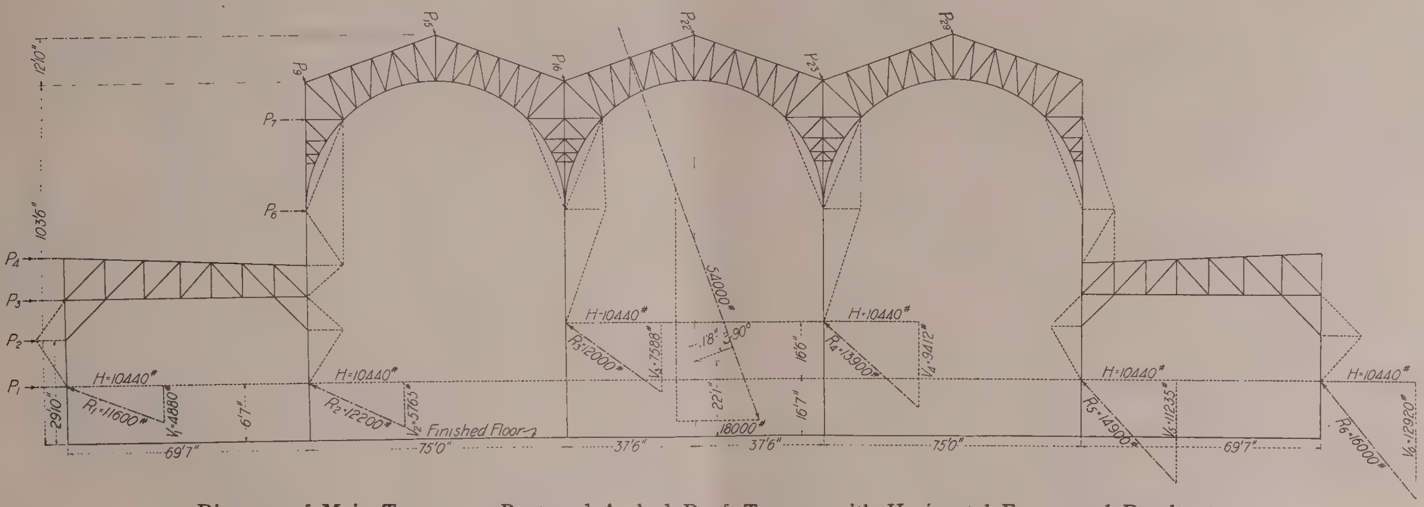


Diagram of Main Transverse Bent and Arched Roof Trusses, with Horizontal Forces and Resultants

The work is on a huge scale. During June an 11-ton column or a transverse truss weighing 7 tons was put in place every twelve minutes of working time by an average daily force of four hundred and seventy-five men. The general features of Machinery Hall were outlined in the Engineering Record of May 17, page 553. The present article discusses the loads and stresses provided for and other matters in connection with the design and erection of the building.

Machinery Hall is located a few hundred feet from the bay shore, on ground filled in for the most part during 1912 by the exposition company. This fill consists largely of sand and was pumped from the adjoining bay shore by hydraulic dredges. Wooden piles, having a minimum butt diameter of 14 in. and an average length of 40 ft., were driven in clusters of from six to twelve as a foundation for the main columns. A timber grillage is employed to distribute column loads to the piles. More than fifteen hundred of these piles were used in the foundation. The bearing capacity of each pile was taken at 20 tons. Before making this assumption, test piles were driven at intervals on the site, and loaded. One test pile supported 30 tons with no settlement.

In designing the main frames the following stresses were provided for: A live load of 20 lb. per square foot of roof surface was assumed for computing the stress in rafters and purlins and the bending in the upper chord of trusses. A wind load of 30 lb. per square foot of roof surface was taken as acting normal to the roof, and Duchemin's formula for wind stresses applied, *P* being taken as 30. A combined dead and live load of not less than 35 lb. per square foot of roof surface on any truss was assumed. The roof trusses were designed separately for both dead load plus live load and dead load plus wind load.

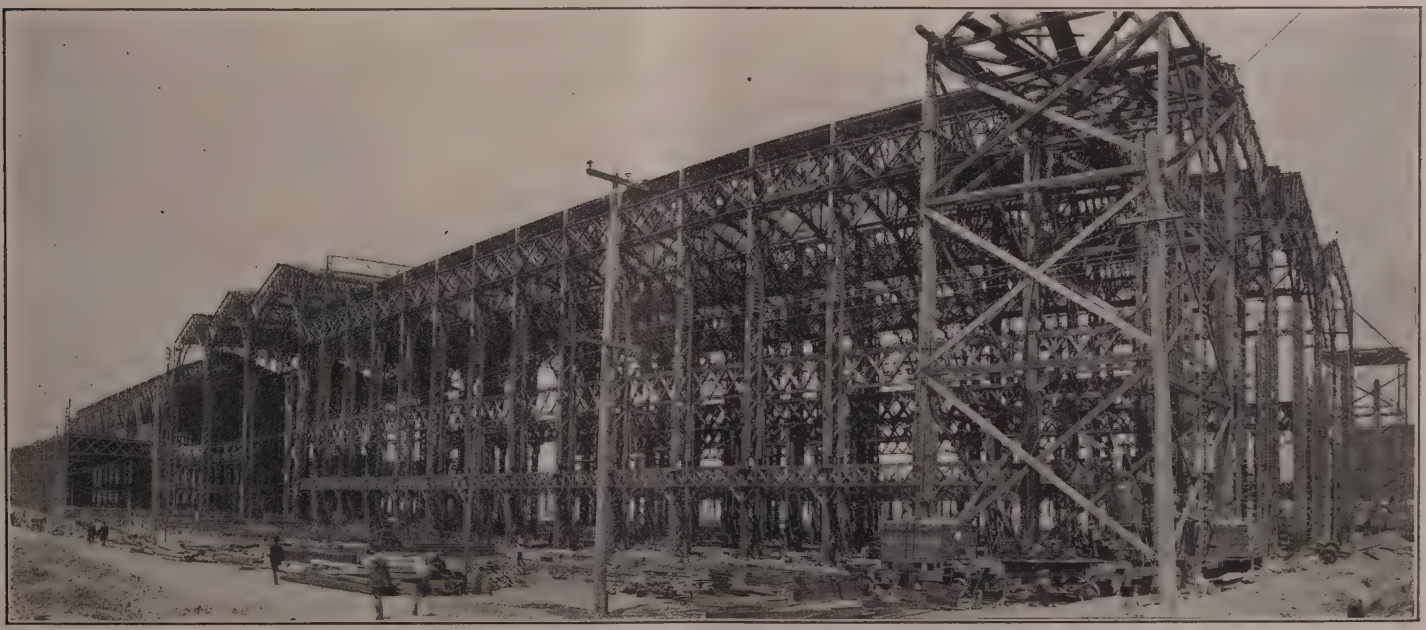
A live load of 200 lb. per square foot of floor was provided for.

Columns and walls were designed for a wind pressure of 20 lb. per square foot of vertical wall surface.

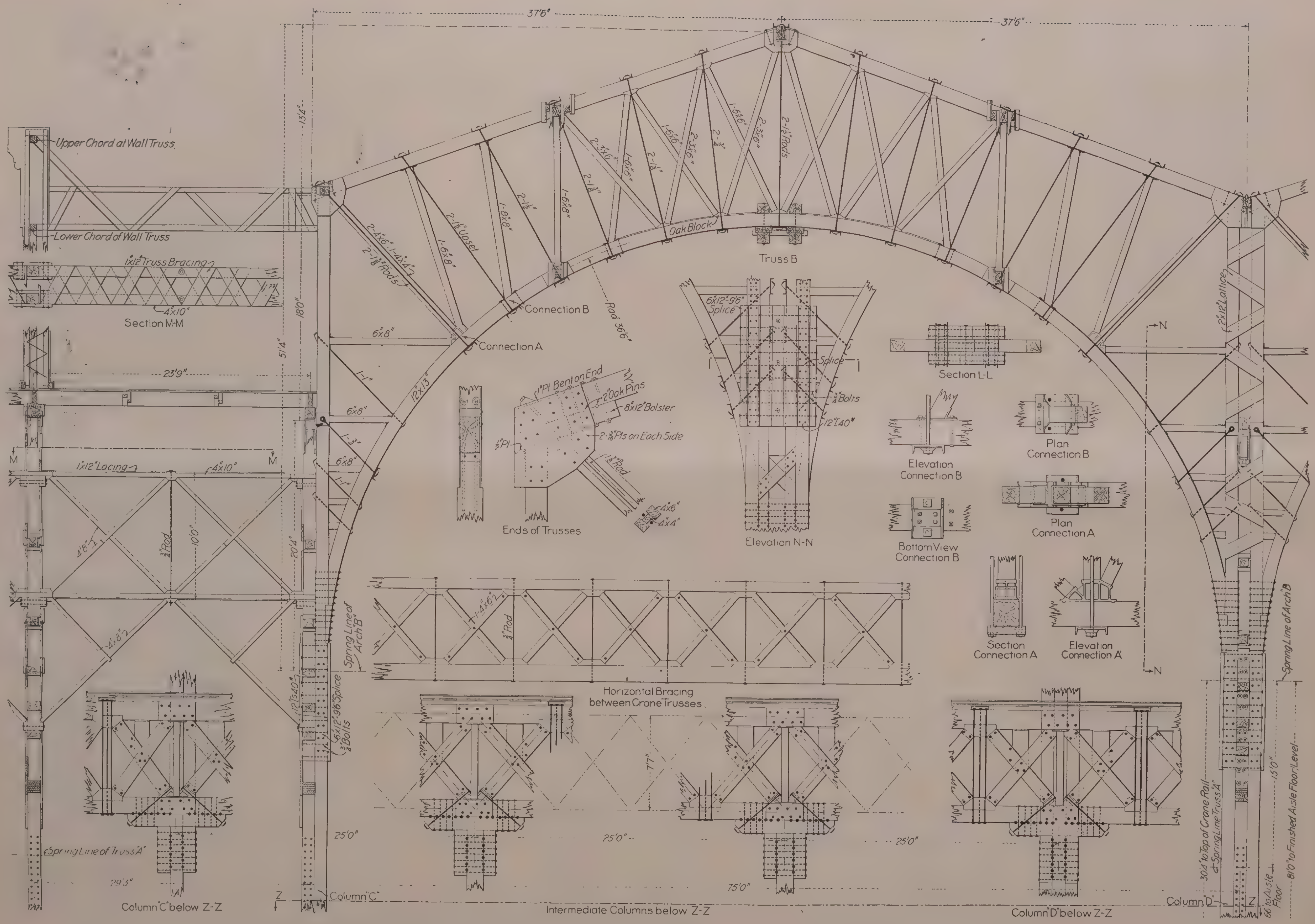
The strength in pounds per square inch of the various materials used in the structure was assumed as follows: Douglas fir, tension, 1200; transverse bending, 1500; shear with the grain, 150; end compression, 1600; compression across grain, 350; modulus of elasticity, 1,500,000.

Steel is used only for tensile stresses and the strength assigned was 16,000 lb. per square inch.

For columns whose length is under fifteen



Tall Columns, Lofty Arches and Bracing Trusses in Wooden Framework of Machinery Hall



Part Longitudinal Section on Main Axis of Building, with Elevation of One of Three Duplicate Transept Roof Trusses diameters the strength was taken as 1200 lb. per square inch. When the length was over fifteen diameters the formula $p=1600$ $(1-1\text{-}60 \times L/D)$ was used, where p=safe load in pounds per square inch; L=length; D=least width of the member in inches. All stresses were increased 25 per cent for wind.

Wind Stresses

The wind diagram was made on the assumption that one main bent of the typical cross-section was a rigid frame. The columns were considered fixed, which gives a point of contraflexure approximately half way between the floor and the foot of the kneebraces. The outside columns of the main nave which received both the A and the L trusses, shown in one of the drawings, may have a second point of contraflexure between the top chord of the L truss and the bottom of the A truss, depending on the rigidity of the connection of the trusses to the columns. This assumption would reduce the stresses in the arched trusses due to wind. However, in order to assure the greatest safety, this condition was not assumed.

For the solution of wind stresses in any bent the general scheme is similar to that outlined by Ketchum in "Steel Mill Buildings." The graphical method of analysis was followed. A slight variation was necessary, due to the fact that in the building under discussion the points of contraflexure of the different posts are not in the same horizontal plane. Hence, for computing the vertical reactions the moments of all external loads must be taken about the center of gravity or the centroid of the points of contraflexure. The actual stresses due to a wind pressure of 20 lb. per square inch, which would be produced by a gale of 70 miles an hour, may differ somewhat from the stresses given by the diagram, but the panels where reversal of stress would occur are accurately determined by this method.

All panels of the arch truss were counterbraced. This redundant system of diagonal struts also tends to make the solution for wind stresses in the truss indeterminate. However, the analysis is believed to be as accurate as the conditions require and any variation is provided for by the liberal safety factor.

Wind stresses tend to produce bending in the columns. Hence, as explained in the Engineering Record of May 17, page 553, they are built as vertical trussed girders, as shown.

In the formula $p=1600$ $(1-1\text{-}60 \times L/D)$ given above the fraction L/D was given a maximum value by assuming L and D to be in the plane in which bending would occur.

Crane Load Stresses

The center bay will be provided with two 30-ton cranes and the side bays each with one 20-ton crane. The crane posts stiffen the columns at the base. Due to the assumption of fixedness of the main columns for wind stresses, there are two critical sections in the column where bending is a maximum, namely, at the base and at the top, or at the foot of the kneebrace.

It was assumed that it would never be possible for the maximum wind load to occur on a post at the same time that the two 30-ton capacity cranes loaded to capacity and hooked together would be over the same post, and, in addition, the 20-ton capacity crane, fully loaded in the adjoining leeward bay, would be in line with the same column. While theoretically possible, this condition is bound practically never to occur. The footings were not designed to meet this condition, for the expense would have been excessive.

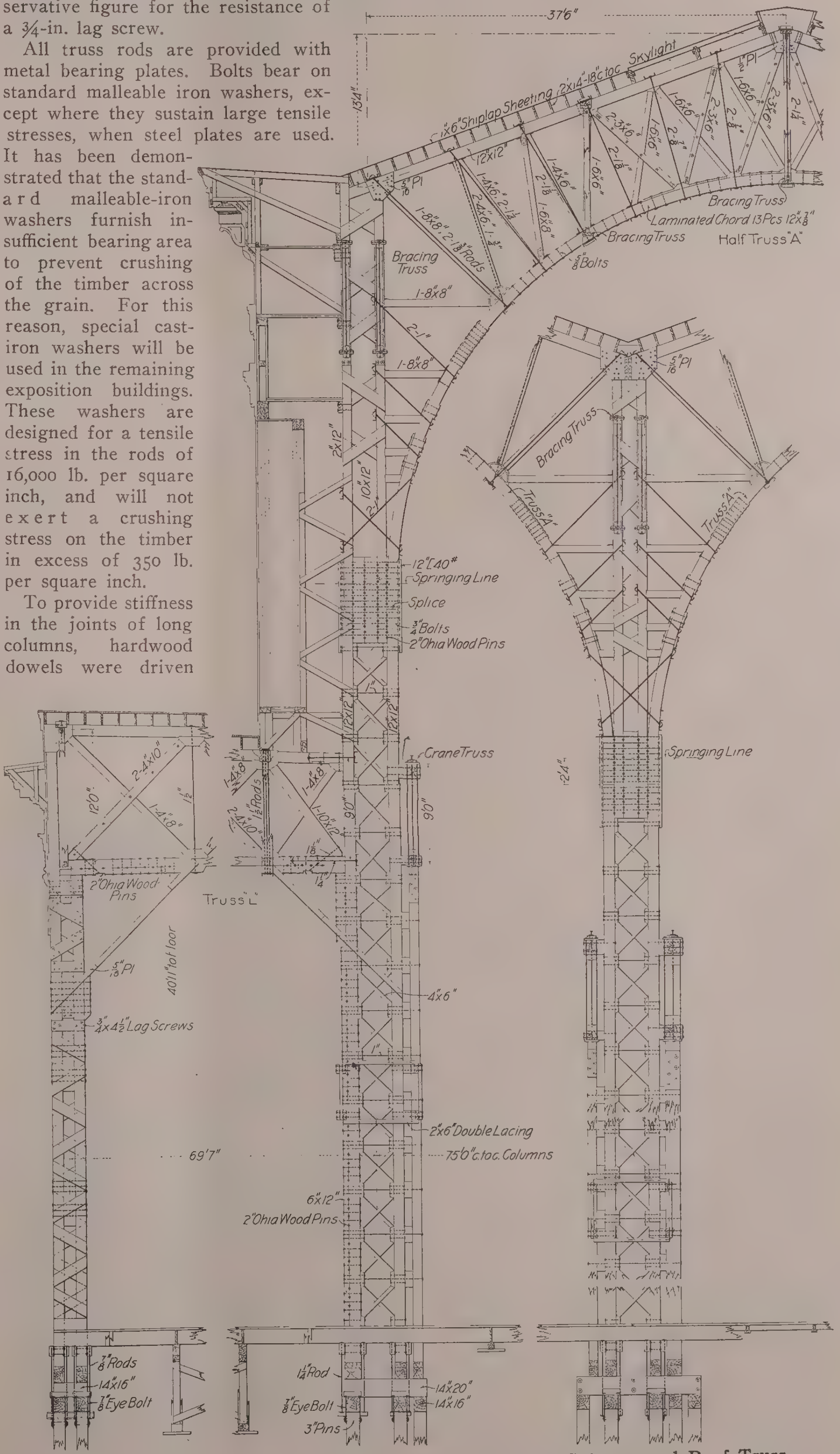
The kneebraces between A trusses and posts are designed to resist either compression or tension. Tension is provided for by means of lag screws bearing on steel plates set against the timbers. The resistance of one ¾-in. lag screw was taken at 2600 lb. per square inch. The value given in Kidder's handbook for the same lag screw is 2100 lb. A series of tests on lag screw joints was made recently at the testing laboratory of the University of California, under the direction of Prof. Charles Derleth, Jr., dean of the College of Civil Engineering. The results of these tests prove that 2600 lb. per square inch is a conservative figure for the resistance of a ¾-in. lag screw.

All truss rods are provided with metal bearing plates. Bolts bear on standard malleable iron washers, except where they sustain large tensile stresses, when steel plates are used. It has been demonstrated that the standard malleable-iron washers furnish insufficient bearing area to prevent crushing of the timber across the grain. For this reason, special cast-iron washers will be used in the remaining exposition buildings. These washers are designed for a tensile stress in the rods of 16,000 lb. per square inch, and will not exert a crushing stress on the timber in excess of 350 lb. per square inch.

To provide stiffness in the joints of long columns, hardwood dowels were driven between abutting timbers and joint plates, as shown in one of the photographs.

Walls and Entrances

The great central entrance, which is 135 ft. high, consists of a structural timber frame which carries the walls, studding, sheathing and plaster exactly as the steel frame of a modern office building carries the curtain walls. In like manner, all the walls of the building are carried on the timber frame, except the outside shed walls. The rear and end entrances are carried in a similar manner. At the end entrances double-arched trusses



Part Transverse Sectional Elevation, with Details of Columns and Roof Truss

and frames are used, one truss being designed to support the roof and the other to carry the cornice and exterior hanging wall.

Outside walls are framed on 2 x 6-in. studs, which rest upon wooden girders spanning from frame to frame. These studs are supported laterally at intervals of about 13 ft. by horizontal wind girders which extend between main columns.

Earthquake Stresses

It is very remotely possible that Machinery Hall, as well as the other exposition buildings, may be subjected to earthquake shocks. It is generally admitted by structural authorities that a wooden-frame building designed for 30 lb. wind pressure would be sufficiently strong and is the best type to resist the disruptive stresses produced by an earthquake as severe as the shock of 1906. An exhaustive study of earthquake stresses was made by Prof. Charles Derleth, Jr., and the results were published in a volume entitled "The Destructive Extent of the California Earthquake—Its Effect upon Structures and Structural Materials." In this volume he states (page 53): "The prime requisite for a structure to withstand earthquake shock is elasticity—that is, the ability to return without damage to its original shape and position after being distorted. It should vibrate without offering great resistance to distortion; in other words, it should yield readily. The wooden-framed and the steel-framed buildings answer this requirement. . . . But structures of brick and stone built of blocks, like brickwork and cutstone masonry, with horizontal and vertical mortar joints, do not answer the requirements of yielding and elasticity to any desirable degree."

A committee of the American Society of Civil Engineers which investigated the same subject in 1906 states: "Sufficient evidence is at hand to warrant the statement that a building designed with a proper system of bracing to withstand wind at a pressure of 30 lb. per square foot will resist safely the stresses caused by a shock of an intensity equal to that of the recent earthquake."

Construction

W. W. Anderson & Company, the lowest bidders, secured the contract for constructing Machinery Hall. The contract price is $451,900. This price does not include lumber, all of which was furnished by the exposition company, or pile foundations. The timber was delivered to the contractors, rough piled, on the area assigned to them. This area consists of the site of the building itself, besides a strip 225 x 1000 ft. immediately west of the structure and a strip 100 x 400 ft. on the north end. To this area were confined the contractors' mills, shops, fabricating platform, steel storage racks, track space and lumber storage space. All of the timber being used in the structure, about 7,500,000 ft., b. m., is handled before fabrication by two stiffleg derricks, each of 10 tons capacity. One of these serves a mill in which a pivoted pneumatic drag saw and an extra-heavy dado machine of special design cut the beveled ends and make all the daps in the large timbers. The other serves a fabricating platform 30 x 280 ft., on which the fore-and-aft trusses are framed. When fabricated, these trusses are stored, or hauled on flat cars by a small locomotive over standard-gage track to the point of erection.

The transverse trusses are made at the south end of the building, and hauled on trucks drawn by horses to the rear of the towers. The columns, 102 ft. high and weighing from 9 to 11 tons, are fabricated on the ground as near their footings as possible. They are then raised into place with little or no shifting by traveling derrick towers.

Splice Keyed with Hardwood Pins

These traveling towers, two in number, have greatly simplified the work of erection. They are 80 ft. in height and on top of each is built a 20-ton stiffleg derrick with a 78-ft. boom. They travel longitudinally in the east and west naves on standard-gage tracks 35 ft. 6 in. center to center. Their booms are on the inner north corners, to enable them to reach the central nave. Erection was commenced at the north end.

Columns at the intersection of the longitudinal and transverse naves similar to two or three of the typical columns bolted together are 123 ft. high and weigh from 19 to 28 tons. These are raised with two hitches, the derrick fall hooked near the top and a fall from a 70-ft. gallows frame hooked about 50 ft. from the bottom of the column. The simple latticed columns and straight-chord trusses of the shed are raised with an 80-ft. boom slung from the columns of the naves already erected.

All hoisting engines used by the contractor are driven by compressed air at 100 lb. per square inch pressure. Three compressors, with a total capacity of 1850 cu. ft. of free air per minute, drive the six hoists, the diagonal saw and the twenty-two wood augurs. An 11,000-volt line which supplies the power is brought to a transformer house near the compressors, and the current stepped down to 440 volts.

Lofty Vaulted Roof of Aisle

The outside of the building will be finished with a travertine stone veneer. This is an artificial stone composed of plaster, sand and pigment. Extensive experiments with this material are being conducted by the architectural department, and it is predicted that when the building is completed it will be impossible to distinguish between the travertine finish and natural stone.

Mr. H. D. Dewell, chief structural engineer for the exposition, designed the building, assisted by Mr. A. A. Brown, chief draftsman, and a corps of assistants. Mr. H. L. Muchemore is engineer in charge of erection. Both design and construction are under the supervision of Mr. H. D. H. Connick, director of works.

Reinforced-Concrete Sea Defenses in England

Groins of reinforced concrete were first built in England in 1907 for the Brighton Intercepting and Outfall Sewers Board. Since then about 10,000 lin. ft. of groins and 2,600 lin. ft. of sea-wall of reinforced concrete have been constructed in that district. In a paper read before the Institution of Civil Engineers Messrs. John Switzer Owens, M. D., and Frederick James Wood, Assoc. M. M. Inst. C. E., have described the work and summarized important principles in connection with the design of such concrete sea defenses.

Formation of Coast

The chalk cliffs in the district vary between 40 and 120 ft. in height; the average batter of the cliff-face is about 1 in 12, and in places the cliff overhangs. The Downs slope toward the sea and terminate in this cliff, so that as erosion goes on the height of the cliff-face increases. The cliffs have been receding at the average rate of about 3 ft. per annum for the 11 years preceding 1907. Along the top of the cliffs runs the main road from Brighton to Newhaven. It is very close to the edge, especially between Brighton and Rottingdean, and as the main outfall sewer from Brighton is laid under it, the steady encroachment of the sea threatens to destroy not only the road but also the sewer. It was chiefly with a view to protect these that the first reinforced-concrete groins were erected.

The problems connected with erosion are here quite different from those in the case of sandy or shingly foreshores. In the latter case the material moves about under the influence of tides and waves, eroding here, accreting there, but on the whole remaining on the foreshore. When chalk is removed by the sea, however, it disappears, the particles being so fine that they are carried away by the currents and entirely lost to the shore. On a sandy or shingly shore, when the erection of groins has to be considered, not only must the probable benefit due to accumulation on the windward side of the groins be taken into account, but also the possible injury resulting from stoppage of the littoral drift, which shows itself as depletion on the leeward side of the groins. On a shore where there is practically no loose material, this question of erosion at the lee side is not of much importance, and groins may with advantage be constructed higher than on a sandy shore. Where the cliff is protected by a shingle bank from actual contact with the waves, erosion is checked. These works were constructed for the Brighton Intercepting and Outfall Sewers Board and the Roedean School Sight and Buildings, Limited. They comprise five reinforced-concrete groins, each 548 ft. long and spaced 500 ft. apart, reaching from the cliff to near low water. Each groin is constructed of columns 16 in. square in cross-section, and spaced 5½ ft. apart from center to center for the first 200 ft. from the cliff, and thence to low water 7 ft. apart. The spaces between the columns were closed by slabs 6 in. thick and 1 ft. deep, dropped into position in grooves molded in the sides of the columns. The slabs were fixed in their grooves by means of cement grout run in from the top after the sides of the opening between the slabs and columns had been filled up with stiff cement mortar. Columns were fixed in concrete in holes excavated in the solid chalk to a depth of 2 to 4 ft., depending on the height of the columns. They stood 8 ft. clear at the cliff, gradually reducing in height to 2½ ft. at the seaward ends of the groins. This method of fixing the columns was adopted in view of the excellent nature of the foundations, and was justified by the fact that out of about two thousand columns put in in this way not one has moved. In shores of sand or soft, easily-eroded material the columns would have taken the form of piles driven to a depth of 10 or 12 ft.

COLUMNS AND SLABS

As it was anticipated that the greatest accumulation of material would occur on the west or windward side, the columns, where over 5 ft. high above the chalk, were provided with raking struts of reinforced concrete on the east side. These struts were the source of considerable trouble later, owing to the severe grinding action of the flint boulders about the base. As the columns were erected, two or three slabs were fixed in each bay, the intention being to increase the height by the addition of more slabs as the shore-level was raised. Since the prevailing drift of material was from the west, work was begun on the most easterly groin. As the columns weighed up to 1½ ton each, and the slabs about 450 lb. to 550 lb., a small sheer-legs was used to move them. The moulds were struck after twenty-four hours, the columns and slabs being allowed to season for about a month before being placed in the work; although it was found that where the columns stood only 3 or 4 ft. out of the chalk, and were not exposed to attrition by shingle, they could be put in safely a week after molding.

In the columns the reinforcement consisted of four 1¼-in. round rods tied together by links of ¼-in. steel wire at intervals of 6 in. The columns had an H shape in plan, the slabs being held between the flanges. In order to support these flanges, short ⅜-in. rods were placed across the main rods and projected into the flanges. It was found that these, though effective, were too easily displaced, and reliance could not be placed on their remaining in their proper position while ramming the concrete into the molds.

The slabs had chamfered corners, and were reinforced by four ⅜-in. rods tied together at 6-in. intervals by ¼-in. steel wire links. The ends of the slabs were tapered to fit the grooves in the columns, and it was specified that not more than ⅛ in. clearance was to be permitted at each side in the column groove, and not more than ¼ in. at each end of a slab; this allowed space for grouting up after the slabs were in position. A groove 3 in. deep below the lowest point of the chalk was cut in the foreshore between each pair of columns to receive the lower slabs and to obviate the danger of under-runs. It was originally intended that the slabs should be left loose in their grooves, so as to provide for this contingency; but as it was found that they could be bedded in a groove cut in the solid chalk, it was considered better to fix them firmly in position.

CONCLUSIONS

A smooth surface, free from projections, should be given to groins and sea-walls. Irregularities on the sides of a groin offer obstruction to the waves; the work is thus exposed to unnecessary stresses, deposition is hindered and attrition of the groin surface is increased. Struts or ties, being open to the same objections, should be avoided where it is not possible to bury them entirely below the surface.

A tough stone should be used for surfaces exposed to attrition shingle. Flint-shingle is unsuitable except for parts which run through sand or are below the surface.

Where it is possible to avoid it concrete work on the foreshore, except in foundations, should not be put in in situ but should be moulded in the form required and well seasoned before being placed in position.

All concrete should be made non-porous by carefully proportioning the ingredients and well ramming. Ordinary rounded gravel contains up to 40 per cent of voids; it is therefore desirable to provide about 50 per cent of sand, both gravel and sand being composed of ungraded particles of as great variety of sizes as possible.

Steel used for reinforcing should be embedded more deeply than for land work. This allows for displacement in construction, for the action of salt water where the concrete covering is not quite impervious, and for abrasion or wearing away of the surface by the attrition of shingle.

Filling the Panama Canal

Flooding the Panama Canal between the Pacific Ocean and Miraflores Locks is being carried out substantially in accordance with plans announced in the "Canal Record" on Aug. 13. On Aug. 25 was begun the flooding of the prism between the locks and a dike 5000 ft. to the south with water from the Rio Grande diversion. It is estimated that the filling will take about five days. Then the dike will be removed by blasting. It is said that there will be nothing spectacular about this operation, which marks an important stage in the completion of the canal. The work preliminary to the flooding of this section involved the completion of the channel 500 ft. wide and 45 ft. below mean-tide level, as well as the finishing of the lower lock gates. The railroad tracks over the dike will be removed before its destruction, leaving the tracks across the lower end of Miraflores Lake, just north of the upper approach walls of the locks, the only means of access to the west side. When the lake is eventually filled, these tracks will have to be abandoned. The removal of all equipment from the west side is progressing as rapidly as possible. The north toe of the dike, from 20 to 45 ft. under water, was thoroughly drilled in preparation for blasting. When the water in the canal section rises nearly to sea level, the destruction of the dike will take place. The ladder dredges Mole and Corozol will complete the work of cutting the prism through the former dike. The arm of the canal thus opened is nearly 5 miles long.

Manufacture of Paving Brick from Furnace Slag

An extensive industry is being developed in the north of England, at Middlesborough, based upon the utilization of blast-furnace slag. Several companies are now engaged in the work. A description of the method pursued in the brick manufacture has been published in a recent consular report.

A suitable manufacturing site is selected near the blast furnaces which are to supply the slag, this plat being connected by an industrial railway upon which the molten slag is carried from the furnace to the molding machine. The latter consists of a metal wheel which may be of any suitable diameter, but which in the case examined was approximately 30 ft., this wheel being supported upon a vertical shaft. The spokes of the wheel are made of round rods and the construction of the wheel itself is quite similar to the wire-spoked wheel used for vehicles. The metal rim upon which the molds are bolted is approximately ¾ in. thick and 6 in. wide. In the plant examined this wheel carried 120 molds 9 in. long, 3½ in. thick and 4 in. deep, which is the standard size for paving brick. A variety of other molds is used, but the bulk of the work is of the paving-brick size.

The molds are made of two pieces, the front end or right side being an arm in one piece which is bolted to the rim of the wheel, while the left side, back end and bottom is another piece. The latter is hinged to the part which is secured to the rim of the wheel and held for casting purposes by a catch on the front end of the stationary piece. On the right side of the mold is cast a lip which assists the operator in more readily striking the mold when pouring the slag.

MOLDING AND ANNEALING

The car which carries the slag is of plate steel with a firebrick lining, the top being covered over with a removable cap, in the center of which is a hole approximately 18 in. in diameter, through which the slag is poured when the car is filled at the furnace. At the bottom of this car is a tap similar to those used upon blast furnaces. The car of molten slag is run alongside the wheel, the trough to the tap extending over the molds; the clay plug is knocked out and the molten slag runs into the mold. As soon as it is filled an operator, by means of a handwheel mounted upon a sheet-steel heat deflector and connected through rods and miter gears to the center of the molding wheel, turns the latter so that the next mold comes under the flow of hot slag, and so on until all the molds are filled. By the time that the wheel has made a quarter revolution the cast bricks have sufficiently cooled so that they may be dropped out of the molds by knocking off the catch which holds the bottom in place.

As soon as they have dropped to the ground they are taken by laborers to the annealing furnaces, into which they are thrown in a promiscuous heap. These furnaces, of which there were six in the plant examined, held approximately 1,100 bricks at one charge. The heat retained in the brick when they are thrown into the furnace, together with a very small amount of fuel, again brings them to a cherry red, and as soon as the furnace has been filled it is closed and allowed to cool gradually, 24 hours usually being required before the bricks are removed.

The capacity of the slag car is approximately 3½ tons, from which 360 to 400 paving bricks are made.

Irrigation of Santa Cruz Valley—Part II

Recovery of Underground Water in Arizona by Wells and Pumps

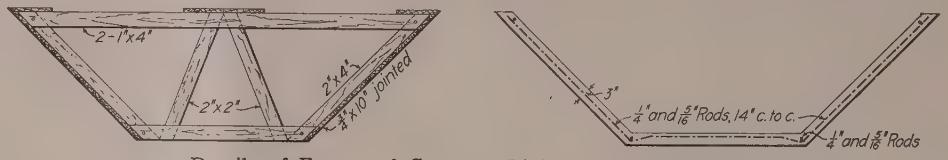
By M. C. Hinderlider, M. Am. Soc. C. E., Chief and Supervising Engineer, Denver

Following the cleaning of the wells, a trench was excavated in the bottom of the open cut into the water-bearing material to a depth varying from 5 ft. at the extreme easterly end of the cut to 13 ft. at the outlet in the west branch of the river. This latter excavation was made for the reception of the reinforced concrete conduit connecting the wells and for the concrete pump-houses, sumps and sand traps. Since all this material was submerged below the water plane of the valley it was necessary to sheet-pile all this work and to operate pumps continuously during the progress of the work. The top of this trench varied in width from about 3 to 7 ft. In some of the shallower depths of trench only one drive of 6-ft. piling was required. The piling consisted of 2x6-in. milled tongue-and-groove Oregon fir supported by 6x6-in. waling and spreaders, trench jacks being used extensively. The piling was driven by hand in the ordinary manner. All trench excavating was done by hand. The equipment used for handling the water during construction consisted of a total of sixteen 4 and 6-in. and one 7-in. Byron Jackson centrifugal pumps belted to three-phase sixty-cycle induction motors of from 10 to 20 hp capacity, mounted on a temporary frame with the pumps. The electrical current was taken from temporary lines strung from a permanent substation of the Tucson Gas, Electric Light & Power Company near the work.

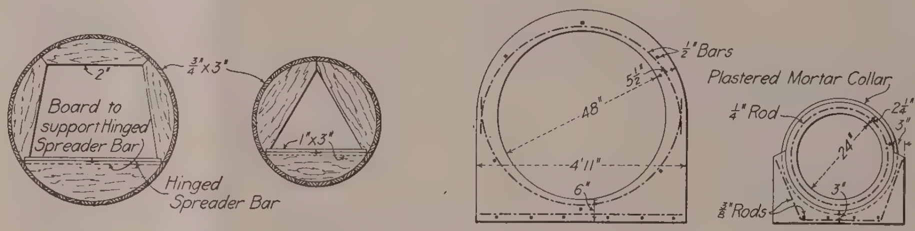
As soon as a section of the trench had been excavated to grade, an open-joint concrete pipe subdrain was laid below the grade of the main conduit for the purpose of cleaning the bottom of the trench so that the concrete for the main conduit could be laid. These subdrains were from 6 to 12 in. in diameter, depending upon the amount of water to be handled. They led to sumps handled by the pumps heretofore described. These sumps were spaced approximately 150 ft. apart, depending upon the amount of water to be handled. In addition to these sumps, temporary pumps were installed on the permanent wells and run continuously. As the work of excavating and unwatering the trench progressed, concrete and steel gangs followed with the construction of the concrete conduits.

The main conduit connecting the wells consists of 600 ft. of 12-in., 900 ft. of 18-in. and 1225 ft. of 24-in. jointed concrete pipe laid in concrete cradles. In addition 800 ft. of 30-in., 500 ft. of 36-in. and 875 ft. of 39-in. reinforced monolithic pipe of the cross-section shown in the illustration was used. There was built, also, an outlet conduit 48 in. in diameter and 1500 ft. long of monolithic construction. No reinforcement was used in the 12 and 18-in. pipe, but all the cradles, together with the 24-in. pipe were reinforced. All monolithic pipe was heavily reinforced to provide against cracks and settlements. In constructing this pipe the invert, consisting of the lower third, was built first, the lower course of trench lagging acting as the outside form. After the concrete had set sufficiently, the invert form was removed, the arch forms set in place and the arch and haunches poured. The jointed pipe was made on the ground near the work by the contractor, who used his own special design of steel forms. After sufficient curing, the inside of each joint was given two coats of neat cement wash, forming a hard interior surface. All pipe was kept thoroughly sprinkled for a period of one week after casting.

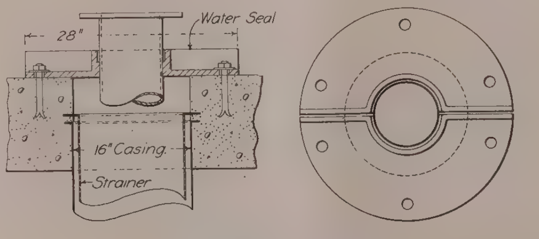
After the monolithic concrete conduits were completed, they were given the same kind of inside wash, which rendered them watertight. Upon removal of the forms few voids were found in the concrete and these were readily repaired. No backfilling over the conduits was allowed for a period of seven days after pouring, and then the backfilling was brought up gradually to the original invert of the open cut. The mixture for the monolithic pipe was 1:2:4, and was placed in the forms in a quaking condition. All material under ¼ in. was screened out, while the maximum dimension of the stone was limited to one-half the thickness of the shell of the pipe. All jointed pipe was made of a mixture of one part cement and four parts sand mixed fairly wet.



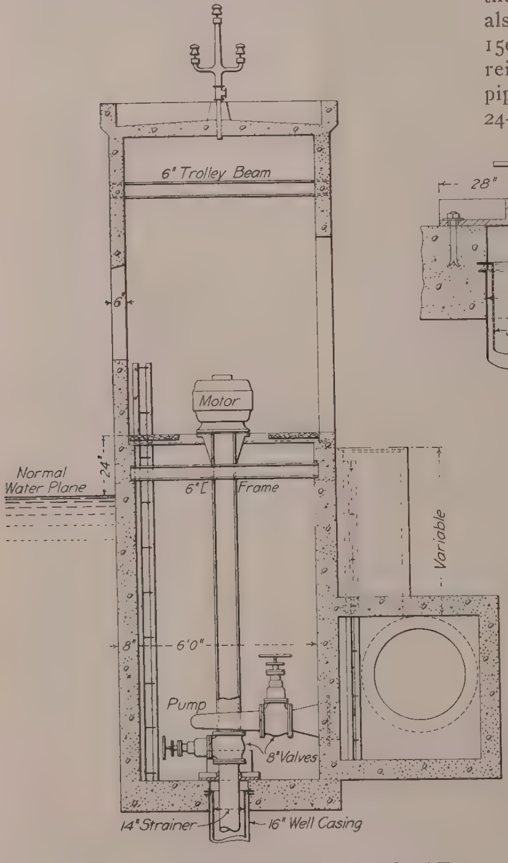
Details of Form and Concrete Lining for Main Canal



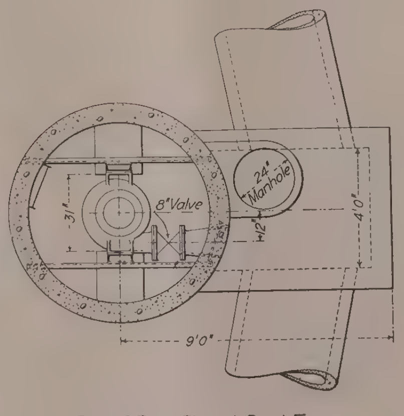
Forms and Sections of Concrete-Collecting Conduit



Collar to Suction Pipe



Sectional Elevation of Pump House and Sand Trap



Plan of Pump Pit and Sand Trap

Plan and Elevation of Pump House, with Sand Trap

PUMP HOUSES

The excavation for the pump-house foundations and adjoining manholes and sand traps progressed simultaneously with that for the conduits, so that when the conduit was completed up to each pump-house the concrete for both sand traps and conduit was run at the same time, thereby forming with the pump-house one monolithic structure. The pump-houses were built circular in plan with an inside diameter of 6 ft. On the side of each pump-house is located a circular manhole 24 in. in inside diameter, which provides an inlet to the rectangular sand trap immediately below, built against the wall of the pump-house. The invert of each sand trap, which is 4 x 6 ft. in plan, is placed 16 in. below the invert of the circular conduits which enter the same. This depression provides means for taking care of the small amount of sand which for some time will be given up by each well, and is designed to prevent the accumulation of sediment along the conduits.

That portion of the pump-house located below the water plane is rendered waterproof by means of a coat of cement mortar applied to the outside and thoroughly washed with two coats of cement wash on the inside. The

Section of Finished Concrete-Lined Canal

Well Casings Projecting from Cross-Cut

maximum hydrostatic head which this waterproofing must stand is 13 ft.

Connection between the well strainer and the pump-house floor was made as follows: Before the floors of the pump-houses were poured the strainers were cut off at the proper height and then split and turned back and cast into the floor as the concrete was run. For sealing off the well permanently from the interior of the pump-house sump heavy cast-iron flanged plates made in halves were bolted around the 8-in. suction pipe of each pump and then bolted to the floor of the pump-house. These plates were provided with proper rubber gaskets for rendering them temporarily watertight, after which they were made permanently tight by means of lead or cement.

Preventing Rise of Water

To prevent the water rising in the pump-house during the installation of the pumps or at any other time when the pumps might have to be dismantled for repairs, an 8-in. flanged gate-valve is provided between the bottom of the pump case and the top of the suction pipe, this valve forming the connection between the pump and the 8-in. suction pipe in the well. The floor level of the pump-houses is placed about 2 ft. above the maximum elevation of the water plane of the valley. This floor supports the vertical motor and the upper ends of the steel guide frame of the pump.

At the junction of the main conduits connecting the wells and the 48-in. outlet conduit in the west branch of the river there is provided a rectangular manhole and sand trap, 4 x 6 in. in plan, the top of which is carried up to a safe elevation above the bed of the river channel. On the west side of the main river channel another manhole and sand trap is also provided for the purpose of taking into the conduits about 4 sec. ft. of underground water which had previously been developed about ¼-mile upstream from the works under discussion.

The pumping equipment consists of eighteen separate units, each consisting of an 8-in. vertical centrifugal pump, mounted in a steel guide frame formed by two 10-in. channel bars supporting and carrying the cast spreader bars, bearings, oiling devices, etc. At the top of the channels is a heavy circular cast-iron spreader plate, which also acts as the base for the vertical motor.

Finished Pump Houses in Cross-Cut

On the discharge side of the pump is an 8-in. valve connecting the pump with a special casting extending out through the wall of the pump-house into the sand trap. This valve is for the purpose of regulating the discharge from the well or for preventing a reverse inflow into the pump-house from the conduits when the pump is out of action. This special casting was grouted into the concrete wall of the pump-house after the pump was adjusted to position.

Equipment

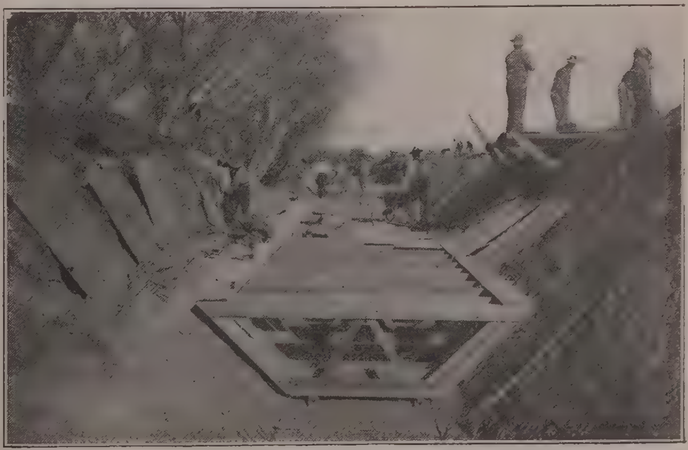
The pumps were furnished under contract by the Byron Jackson Iron Works, of San Francisco. The specifications called for a capacity of from 1000 to 1100 gal. per minute under a working head of from 16 to 20 ft., and required a net pump efficiency at the coupling of 54, 56 and 58 per cent, depending upon the head. Under test these pumps showed an efficiency of from 62 to 67 per cent, which, for the very low working head imposed, was considered very good.

Eight General Electric and ten Crocker Wheeler three-phase, sixty-cycle, 440-volt. 10-hp motors running at 580 r.p.m. were used. These motors are direct-connected to the pumps by means of standard flexible leather link and pin couplings.

Reinforced concrete 6 in. thick above and 8 in. thick below the floor line is used for walls in the 6-ft. diameter pump-houses. Ample screened openings are provided for ventilation in that climate where the temperature at times rises to 112 deg. Fahr. in the shade.

At the top of each pump-house is provided a traveling steel trolley supported on a 6-in. I-beam, which may be used for dismantling

Trenching for Concrete Conduit in Cross-Cut



Forms and Reinforcement for Canal Lining and assembling the machinery where required. The inlet to the house is through double steel doors provided with proper locking devices.

The main canal which conveys the water from the 48-in. outlet conduit of the recovery system to the lateral system is about 9 miles long. There are no unusual features connected with the construction of this canal with the exception of the structures along the upper 2½ miles. The first 3 miles of this canal consist of an enlargement of the old Manning ditch. This ditch was very crudely built a number of years ago. For the most part the gradient was very low and poorly equalized while the location of the ditch through a part of the city inhabited largely by Mexicans, running as it did through alleys, back yards and under houses with poorly defined rights of way, made the relocation a rather troublesome matter. From careful measurements made during two irrigation seasons it was found that the loss of water in this and other ditches in the valley amounted to over 5 per cent per mile of ditch. This great loss appeared to be caused not only by seepage but by the evaporation from and the transpiration of moisture by the rank growth of vegetation which in that warm climate grows profusely and soon fills the canal section. The loss of water, the necessity for repeated cleaning of the canal each season, together with the confined limits of the right of way available for enlargement, made it desirable to line the first 12,650 ft. with concrete. In lining this canal three different cross-sections were used, due to the varying gradient between certain control points which were fixed by existing railroad crossings and other structures along the canal.

CANAL SECTIONS

The three cross-sections adopted were: Bottom widths 4 ft. 9 in., 3 ft., and 2 ft. In each case the net depth of section was 3 ft., the side slopes 1 on 1 and thickness of lining on both bottom and sides 3 in. The concrete was reinforced by ¼ and 5/16-in. round rods bent to conform to the cross-section and spaced transversely every 14 in., while four longitudinal rods of like size were used to support the transverse rods and take up temperature strains.

The lining was built in 12-ft. sections, a ¾ x 3-in. expansion joint of soft pine being used at the ends of each section. After the canal section has been dressed to conform to a templet, the reinforcing steel was placed. The wooden forms were then set in place and bolted together. Steel plates of No. 12 gage metal, about 2 x 4 ft. in size, were then slipped down beside the forms and allowed to rest upon the dressed canal banks. These plates were used to pour the concrete upon in placing it in the side walls, to prevent dirt falling into the concrete as the work progressed. To retain proper spacing so as to secure a 3-in. thickness of lining, 2 x 3-in. spacing bars of wood were inserted between the form and the metal plates, two spacing bars being used for each plate. As the concrete was poured, the plates and spreader bars were gradually drawn out, while the tamping proceeded continuously. The forms were allowed to stand over night, which gave the concrete ample time to harden.

MOVING FORMS

In moving the forms up from the rear, a two-wheeled truck was used, which ran along runway boards on top of the forms ahead. After the removal of the forms, the bottom of the ditch and lower edges of the side walls were thoroughly cleaned and flushed with water. The bottom was then poured and brought to grade by means of a 14-ft. straight edge which rested on the 1 x 3-in. expansion joints spaced 12 ft. apart. After the floor had hardened sufficiently the walls and floor were gone over, cleaned and pointed up, after which the walls were given two coats of neat cement wash.

All the concrete was hand mixed and delivered to the forms in wheel-barrows, the maximum length of travel from the mixing board to the forms being about 200 ft. The mixture used was 1:3½:4½. The aggregate consisted of crushed stone passing through 1½-in. mesh screen and refused on a ½-in. mesh. The sand was taken from the river bed near at hand and was generally rather fine. The specifications called for a 1:3:5 mixture, but this mixture did not furnish sufficient mortar to give a satisfactory surface to the concrete.

In the beginning but one gang was employed on this lining. As the work progressed, additional gangs were organized until the contractor was running four gangs. The average rate of progress per 10-hour run per gang, after the forces were well organized, was about 200 ft. of finished ditch, the average amount of concrete being 14 cu. yd. Mexican labor was used almost entirely. Water was piped either from a pump or from city hydrants usually several hundred feet away. The quarrying, crushing and screening of the stone was done at a quarry located near the center of the work, the haul ranging from ¼ to nearly 2 miles.

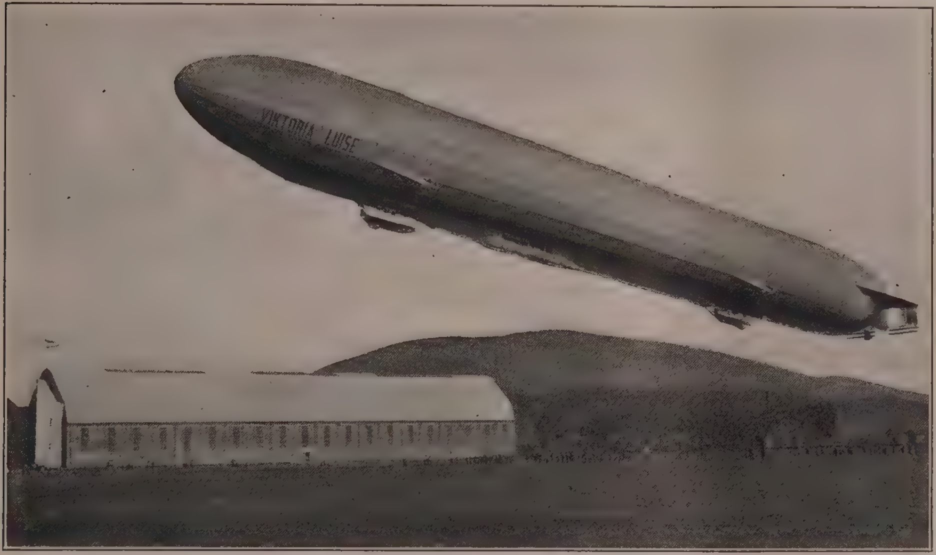
All the concrete work was done under contract by the Arthur S. Bent Construction Company, of Los Angeles, Cal., while the earth work was handled by Chadwick & Deyo, of Tucson.

Cumberland River Bridge

The Cumberland River Bridge of the Louisville & Nashville Railroad is approximately 3000 ft. long, including a viaduct approach at each end, one 300-ft. and three 200-ft. through-truss river spans and three 135-ft. deck truss spans, all of which have riveted connections except the pin connected 300-ft. span. The substructure is entirely of concrete, of which there are about 1700 yd. which were built in cofferdams of interlocking steel sheet piling under an average head of about 16 ft. of water. All of the foundations were carried down to bed rock to a depth of 130 ft. below base of rail. In three of the cofferdams considerable difficulty was experienced from encountering open conduits leading to the city waterworks pumping station close to one end of the bridge. The concrete was mixed in a plant on each bank of the river and was carried by hauling engines to the different piers. All of the truss spans are erected on falsework built with an overhead traveling stiff-leg derrick. It is expected that the erection will be completed this fall. The steel superstructure was fabricated by the American Bridge Company and erected by the Foster-Creighton-Gould Company of Nashville, Tenn., which has also constructed the substructure.

Cumberland River Bridge, with Concrete Piers 130 Feet High Above Rock Bottom

STANDARD GRAVEL CONCRETE specified by the Illinois Highway Commission for general bridge work may be used in place of broken stone and sand in structures built for the State of Illinois. It is to be of three classes—X, A and B, proportioned respectively 1:2:3½, 1:2½:4 and 1:3:5. For Classes X and A all material which passes a ⅛-in. screen will be considered sand and all material which is retained on a ⅛-in. screen and passes a 1-in. screen will be considered stone; but at least 40 per cent of the stone shall be retained on a ½-in. screen. For Class B all material which passes a ¼-in. screen will be considered sand and all material which is retained on a ¼-in. screen and passes a 2½-in. screen will be considered stone; but at least 40 per cent of the stone shall be retained on a 1½-in. screen. In all classes of concrete, if the volume of sand is found to be less than 60 per cent of the volume of stone, sufficient sand shall be added to bring up the proportion of sand to stone to 60 per cent. If the volume of sand is more than 60 per cent of the volume of stone, sufficient stone shall be added to reduce the proportion of sand to stone to 60 per cent, or sufficient cement shall be added so that the volume of cement to sand shall be as required.



"Viktoria Luise" about to Start on One of Her Trips

Over Germany in an Airship

Non-Technical Account of the Impressions of a Staff Correspondent of the Engineering Record Aboard the "Viktoria Luise" of the Zeppelin Fleet

Every engineer knows something of the airships which plucky old Graf Zeppelin has worked out from experiment to practical success at the cost of years of labor and of his large private fortune. But most of this knowledge is of a general character, touching the principles involved rather than the actual working of the thing itself.

To begin with, air travel is now an everyday performance, for the Deutsche Luftschiffahrts-Aktien Gesellschaft is operating regularly three great airships in regular passenger service with established home ports at Hamburg, Leipzig and Frankfort. Each makes from two to four daily runs, besides long flights across country at occasional intervals if wind and weather permit. The fleet consists of the "Hausa" dividing its time between Hamburg and Potsdam, the "Sachsen," with headquarters at Leipzig pending the completion of a suitable house at Dresden, and the "Viktoria Luise," with headquarters at Frankfort and a station also at Baden-Baden. All three are much alike, differing only in minor details, so that an account of one is typical of them all.

They are all of the rigid frame type characteristic of the Zeppelin construction, are driven by four propellers, two forward and two aft, placed well below the central axis, and have an ordinary working speed of 35 to 40 miles per hour in still air and proportionately greater or less speed when running with or against the wind. This means that the ships can make headway in case of need against a pretty stiff blow, although as a matter of fact they are not operated on their ordinary trips if the weather looks squally to a serious degree. I think that this hesitation is due more to the question of getting out of and into port without risk of damage than to the fear of the actual wind.

DETAILS OF "VIKTORIA LUISE"

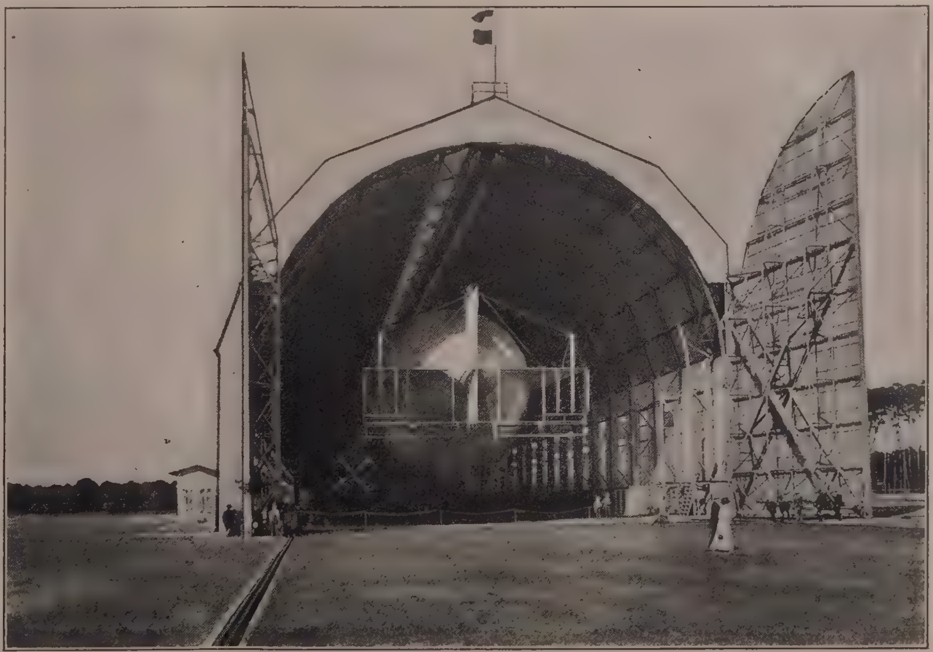
At all events when I booked for a run of 150 km. or so on the "Viktoria Luise" I left my hotel address so that I could be notified by telephone if delay became necessary on account of bad weather, but the afternoon was calm and clear. About three o'clock I took a taxi and in twenty minutes reached the entrance to the airship field, in the middle of which loomed up an enormous arched-roof building like all the barns in a country rolled into one, a frame buiding with a steel-truss roof and with gigantic barn doors ready to swing outward.

Inside was the "Viktoria Luise," and her truly colossal size showed at its fullest under the great arched roof and made one catch a sudden breath. One of the pictures gives a feeble idea of the way she loomed up. To be specific, she is 455 ft. over all and 46 ft. in diameter, and has a capacity of something over 670,000 cu. ft. The bow is blunt, like that of a Whitehead torpedo, the middle body very long, about 300 ft., I should think, and the stern again somewhat blunt like the bow and provided with big rudder planes. Forward and aft too are slightly oblique planes which serve as bilge keels and give somewhat of an upward thrust when the ship is under way. Between the two motor cars the body of the ship is smoothly molded into a sort of broad keel amidship in which is built the passenger car, about 8 ft. wide by 25 ft. long, finished in mahogany and provided with the fullest kind of window space along the sides.

There are three motors, each of 145 horsepower. The one in the forward motor car drives the forward pair of two-bladed propellers, each about 3 m. in diameter. These propellers are placed just clearing the body of the ship with their tips, and turn at 500 revolutions per minute full speed. The after motor car contains the other two motors, each driving a propeller of similar diameter, but with four blades. Steering is from the front car by cables reaching the rudder planes aft. These, as well as the propellers, are shown in the picture taken just before the ship was to emerge, stern first, from the house. Note the elaborate truss structure of the enormous doors which swing out on quadrantal tracks below. On the left is the track used in maneuvering the ship when necessary.

"TRIMMING SHIP"

By 4 p.m. a considerable gallery had gathered to see the start, at a small admission fee, and was alternately gaping at the ship and drinking beer, since smoking was not permitted beyond the entrance to the grounds, 200 yd. away. The public is kept out of the space immediately under the ship, but has a clear runway along the sides. Presently the preparations for starting began. One by one the motors were tried out with a terrific whirring of the propellers and everything about the motor cars was overhauled. Then began the most interesting part of the preparation—the establishment of balance and flotation. The huge bulk of the ship is made up of eighteen compartments worked into the main frame; this facilitates the adjustment of horizontal balance. The accurate adjustment of balance and flotation to the existing conditions plays a far more important part in successful flying than one would think offhand. Indeed in these regular trips I will hazard a guess that it is pretty nearly the whole thing. For with a normal carrying capacity of about 22 tons, of which nearly two-thirds is fuel when the tanks are full, large variations in lifting power must be allowed for. And when one realizes that the lifting power of this enormous body of gas diminishes by about 100 lb. for each 20 m. of elevation and nearly the same amount for



Hangar and Stern View of the Airship, Showing Propeller Arrangement each degree rise of temperature the need of fine adjustment of ballast is evident. On the other hand it is clear that there is considerable inherent stability in the matter of height.

They began operations by running out water ballast—it is cheap and does not hurt if it drops on the heads of people below—and then shifted some of the sand bags stowed along the keel. Then more adjustment of water ballast, the ship being lightly steadied by ropes until she was in nearly neutral equilibrium. Finally we climbed into the car by a short step ladder and planted ourselves comfortably in wicker armchairs to await further developments. Then began a final and apparently very careful adjustment of ballast, after all hands were aboard. The regular crew numbers nine, and on this occasion there were nine passengers, including one lady.

Shadow of the Airship upon Cultivated Land

Roofs of Frankfort as Seen from Airship

The Start

At last everything was adjusted. Towed by a large gang of men on ropes forward and aft, the ship, just poised clear of touching, slowly floated out through the open doors and as slowly drifted a hundred yards to the left of the track. Then the passengers were asked to step to the after end of the cabin to trim ship by the stern a bit, the motors were started and without any really perceptible motion the big craft slipped away from the ground on her flight. She gained height rather slowly, circling over the city at a level perhaps 100 m. above the roofs, moving without rolling or swaying or the least trace of vibration. Even the noise of the propellers reached us only faintly. The lifting power in these low flights seems to be mainly dynamic from the vertical steering and the upward component from the steadying planes rather than from the purely static lift of the gas. Indeed, were there not a large margin due to the vertical steering the necessary loss of weight from the consumption of fuel as the journey progressed would be altogether a source of considerable trouble. Loss of fuel has ultimately to be compensated for by loss of gas, but the vertical steering evidently helps out materially. In working at their rated capacity the motors must eat up nearly half a ton of petrol in two or three hours of an ordinary run.

One of the pictures shows the top view of the city at this stage of affairs—flying at a height certainly not exceeding the length of the ship. By the way, photographing from an airship is no joke, for there is little clue to the actinic value of the light and the ship is traveling at the speed of a railway train, so that exposures have to be very short. I worked at F6.3, using a focal plane shutter with an opening of 3 cm and operated at its top speed and got fully exposed negatives in spite of starting at 4:45 and landing at 7:10 p.m. On the whole there is better light than there seems to be.

Full Speed Ahead!

Presently we headed eastward, came to full speed and struck out across country toward Wiesbaden. A glance at the big aneroid in the cabin showed that we were rising toward the 200-m. level. At this height and full speed there was still no rolling, there being nothing much but our own head wind to contend with, and only a slight tendency to pitch gently, a tendency easily controlled by the rudders. The period of the sway was long, say 20 to 30 seconds, and it only happened now and then. The motors worked with wonderful smoothness and the propellers whirred steadily, driving us on.

The most curious thing about the whole affair was the utter absence of a marked sensation of any kind. You are looking down as from the top floor of a skyscraper and the landscape is slipping along underneath and that is all there is to it. One sees the yellow harvest fields with top views of working peasants and of rabbits running to cover. The hens scattered with much flapping of wings, cattle took to their heels for the farthest corner of the pasture, and geese waddled desperately for shelter. Just why all this I did not at first understand. The black shadow of the ship swept over the fields like a threatening cloud, and the animals fled in all directions. Later, at Leipzig, I found out, for the great "Sachsen" sailed right over the garden of the hotel as I was sitting at supper, and although fully 150 m. high she certainly did make an infernal racket. In the ship, out in the free air, the noise is trivial, but on the ground one gets the full benefit of it.

Passing over Wiesbaden we ran down the Rhine to near Mattenheim and there swung about and followed up the river homeward. All the time we were running with remarkable steadiness and at a level of from 150 to 200 m. As we neared the home port we tilted slightly, almost imperceptibly, downward, the propellers slowed down and then stopped—dropping us at the starting point as gently as a leaf drops. A force of men laid hold of the ropes as in starting and steadied the ship while we descended two by two, allowing time between pairs to adjust the ballast.

The trip is immensely interesting, but not in the least sensational; everything goes too smoothly. Despite the beautiful behavior of the ship in the air, starting or alighting in a blow would evidently be a precarious business. It would not take much of a cross wind to put ten tons' pressure or so against the ship and getting away would be something of a problem, to say nothing of the difficulty of getting out of the house. The fact is that a wind in an unfavorable direction keeps the ship at home. Of course, once in the air, I fancy she would get on well enough, with more unsteadiness than I have noted, and in descending she would of course come up into the wind to her moorings. Getting up in a wind would probably mean heading down it and cutting loose a good bit of ballast at the start. The motive power and steering qualities are certainly most excellent. I hear that in a new military ship of similar design they will more than double the horsepower, probably raising the speed to more than 50 miles per hour and so gain maneuvering power in bad weather.

The present passenger ships are tenderly handled for obvious reasons and the "Viktoria Luise" has a record of 300 trips with passengers. The casual observer thus gains an idea that she is very much of a fair-weather craft —an idea which I think is exaggerated. It strikes me that she could ride out a pretty bad blow if necessary, if once at a level high enough to have free space in which to work. It might be a case of run for it, however, and waiting a chance to circle homeward later. Personally I wouldn't mind trying it a bit.

Usefulness in War Time

In the military sense it is very hard to judge what importance to attach to the "Zeppelin." Hitting it at any ordinary range is like hitting a barn from the inside and its only security from gun-fire lies in night attack or in working at very great elevation. In the first case its first attack is hard to deliver, assuming that in case of such a chance lights are ordered out. In the second, it is very vulnerable to attack from aeroplanes, much faster and much harder to put out of action. And the more one knows about explosives the less one seriously considers the military damage done by the few tons of explosive an airship can carry. Much property could doubtless be destroyed, but the fighting power of a fortress already secure against high angle fire from shells is not likely to be materially diminished by airships.

The chief value of airships of this class would lie in their moral effect in spreading terror, even unreasoning terror, and thus causing efforts toward peace. In some special service they might, too, be valuable on account of their long radius of reasonably certain action. At all events they will assuredly be tried out and will play a part in the next great struggle. They are of possible value, too, in time of peace for special kinds of work in emergencies, and from any point of view they are worth while as evidence of a measure of mastery over the air and as proof of the victory that is eventually won by determined effort in face of enormous difficulties. The story of Graf Zeppelin's long continued efforts and final success is in itself an inspiration that is worth much to the world.

Four Swiss Tunnels

Four important tunnels are at the present time in course of construction in Switzerland, not counting the Lötschberg, which was opened for international traffic on June 15. Of the tunnels in progress the most important is the second Simplon gallery. The progress in this bore is slow because blasting can be done only when no train is passing through the existing tunnel. On the north side, where about one thousand men are employed, 774 ft. were blasted out during April, and 630 ft. were driven on the south side.

Considerable anxiety is felt, it is said, regarding the Frasne-Vallorbe tunnel, most of which is on French territory. During the winter work was suspended for a time owing to floods, and it was only recently resumed after further delays from the same cause. It was planned to have the headings meet at the end of March, but some 1950 ft. still remain to be taken out. It is expected that the completion of the tunnel will be delayed about six months.

Nearly 40 per cent of the Hauenstein Base tunnel has been taken out, but only 0.6 per cent is actually completed. The temperature of the rocks is fairly high, especially on the north side.

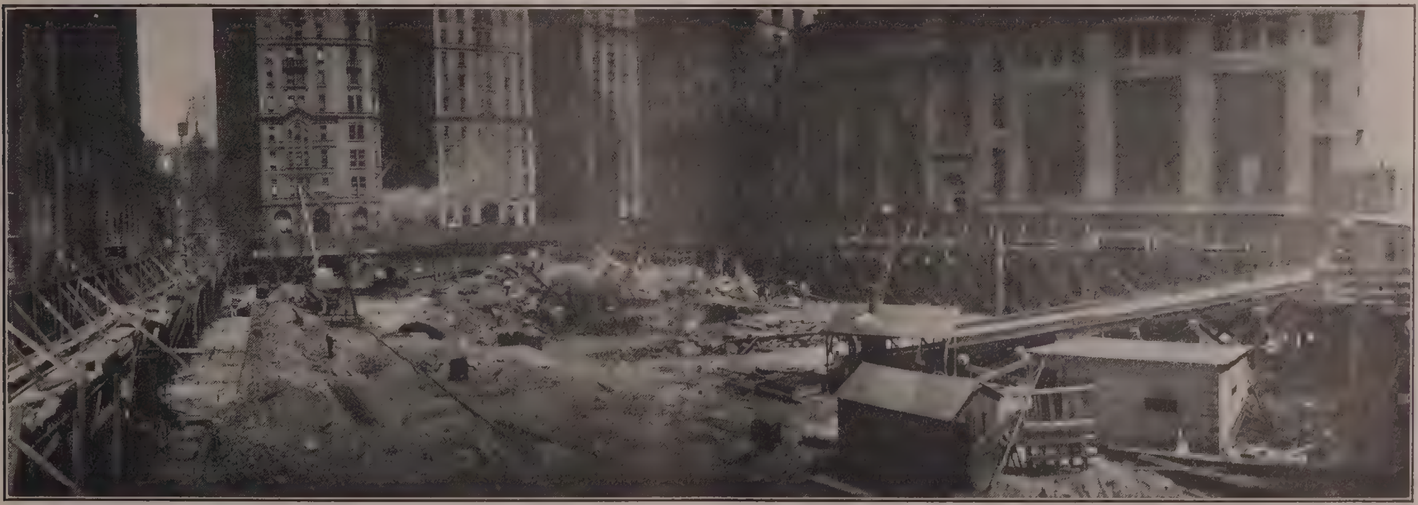
At the Münster-Grenchenberg tunnel work is progressing without interruption and no complications have been reported.

Excavation and Substructure Plant for the Equitable Building

Work is now under way on the construction of a 167 x 312-ft. 38-story office building at the site of the old Equitable Insurance Company's building in New York, which was destroyed by fire more than a year ago. The removal of the massive masonry walls by the George A. Fuller Company occupied several months, after which the O'Rourke Engineering Construction Company, contractor for the new substructure, had about 6000 cu. yd. of heavy masonry brick and concrete cellar floors up to 8 ft. in thickness to blast away before it could commence the general excavation, which will involve about 50,000 yd. and extend to a maximum depth of about 50 ft. below the curb.

Excavation to Water Level

The old cellar floor was about 16 ft. below the curb and after an opening had been made Marion and Thew steam shovels were installed in the pit and excavated and loaded nearly all of the masonry and the fine underlying sand into two-horse wagons drawn up an inclined causeway to street level by a hoisting engine located on a tower in the excavation. An average force of fifteen teams thus handled 10,000 yd. of sand and broken masonry in the month ended July 20, carrying the excavation down about 25 ft., nearly to ground-water level. Several Ingersoll-Sergeant rock drills were installed for breaking up the old floor.



Steam-Shovel Excavation Carried Down Nearly to Ground-Water Line and Piles Driven for Traveler Tracks

Borings indicate that the soil consists of fine sand without obstructions down to a 12-ft. layer of hardpan overlying bed rock at a depth of about 80 ft. below the curb. The sand contains a very large amount of ground water, which it is proposed to exclude by a cofferdam, consisting of thirty-seven wall caissons inclosing all sides of the rock and extending from about water level to rock. The corner caissons will be about 12 ft. square and the intermediate ones will be about 25 ft. long and having a thickness of 6 ft. They will be set close together, with the outer faces on the lot lines, and will be bonded together by a system of wells between the adjacent ends, filled with concrete, as was done by the same contractor for the New York Stock Exchange and other buildings. These caissons will serve to support the wall columns, and after their completion the general excavation will be carried down in the open, the eighty remaining interior column piers probably being built without caissons. The concrete caissons will be sunk by the pneumatic process and will require about 12,000 yd. of excavation and 11,000 yd. of concrete.

The location of the building, which occupies the entire block bounded by Broadway, Nassau, Pine and Cedar Streets, facilitates construction in that the clearance from adjacent buildings is great enough to diminish the danger of undermining and eliminates the necessity for underpinning so often called for in deep city foundations. It also permits the installation of a system of travelers and traveling derricks on each of the bounding streets, which will command all of the lot area except a limited portion in the center. There will be erected two traveling towers on Pine Street, two on Cedar Street and one on Nassau Street, each carrying two derrick booms and spanning the street. One rail of the track will be laid on the curb farthest from the excavation and the other rail will be supported on piles 50 ft. long, of which about one hundred and fifty were driven for this purpose in the excavation 2 ft. outside the lot lines, thus relieving the sides of the pit of any dangerous surcharge. The Broadway sidewalk will be protected by an unusually heavy bridge, also supported on piles, and carrying on its deck a track for a two-boom steel traveling derrick besides which two or more stiffleg derricks will be shifted from place to place in the pit as required.

General Equipment

Ransome machines installed at street level will mix the concrete delivered by the derricks to the caissons. All of them will be operated by General Electric motors, which will also be used for the Lidgerwood hoisting engines on the derricks and travelers and for the two Ingersoll-Sergeant air compressors, set tandem in a narrow space 80 ft. long in the Broadway sidewalk vault, where they offer no obstruction to the caisson sinking. This arrangement is estimated to cost no more than steam power and offers considerable advantages in convenience, lack of obstruction and the elimination of smoke nuisance. The work is being executed by a force of about four hundred men, working continuously in three eight-hour shifts, and it is expected that it will be completed ready for steel erection by Jan. 1.

The work is being done under the direction of Mr. E. R. Graham, architect, and Mr. Daniel E. Moran, consulting engineer. The Thompson-Starrett Company is the general contractor.

Pneumatic Caissons for Scotia Dam

How Foundation Methods Employed for Substructures of Lofty Office Buildings Were Applied to the Work of the New York State Barge Canal

The Mohawk River, which is made to serve as a portion of the New York State Barge Canal, is being improved in the vicinity of Scotia, near Schenectady, by the construction of dam 4 to maintain a navigable depth of water in the pool and by the building of lock 8 to transfer boats between the upper and lower levels. The character of the river bottom at this point makes the foundation work so difficult and expensive that the original contract for executing it by ordinary methods has been abandoned, and the work is now under construction by special methods, involving the use of pneumatic caissons, an unusual application of such operations for dam building. The cofferdam and excavation for the lock, although involving only familiar construction practice, have developed rather unusual combinations which are being successfully applied on a large scale.

Conditions and Preliminary Works

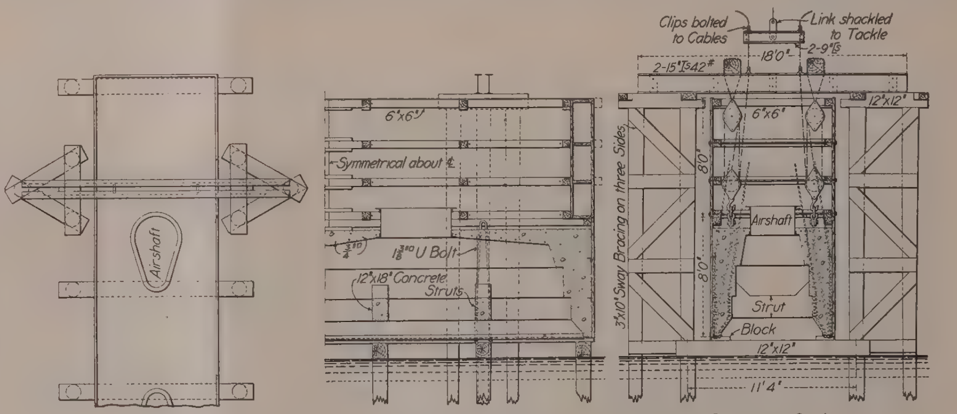
At the dam site the river is about 900 ft. wide and from 10 to 20 ft. deep, with a current of three or four miles per hour. The river bottom consists of about 4 ft. of very tightly cemented coarse gravel, 20 ft. of loose gravel, and a 30-ft. impervious stratum of clay and gravel. The Erie Canal, about 70 ft. wide, 8 ft. deep and 30 ft. above mean water level of the Mohawk River, is located parallel to the river and 50 ft. from it on the south bank, and will be abandoned after the completion of the new dam and lock. The north or Scotia bank, 15 ft. above water level, is quite flat and affords a convenient location for the installation of the principal construction plant.

The channel portion of the dam consists of a concrete section 728 ft. long, composed of twenty-four reinforced concrete pneumatic caisson piers sunk to a depth of 50 to 80 ft. below low-water level. At the south end this construction is extended a short distance into the bank with a wooden sheet pile core-wall, intended to intercept any seepage and prevent undermining. At the north end it is extended about 150 ft. by a paved earth embankment with a wooden sheet pile core-wall which overlaps the caisson construction about 100 ft.

The downstream face of the dam is protected by rip-rap pavement and portions of the concrete construction are made to serve as piers of a highway bridge with the same alignment as the dam. The south end of the dam passes under the 90 x 418-ft. concrete lock No. 8 for which it forms a portion of the foundation. For several hundred feet above and below the lock the river bank is protected by a concrete revetment wall and rip-rap toe.

The twenty-one regular caissons are about 8 ft. wide and 35 ft. long, sunk alternately with a clearance of about 18 in. between their adjacent ends, which, after the caissons are sunk, form partial wells, completed under pneumatic pressure and concreted to form interlocking connections between the separate units of the dam.

This feature corresponds closely in design and construction with the wall caissons used to enclose the area of the lot and support part of the columns in various tall office buildings in New York which have been described from time to time in the Engineering Record. The caissons under the lock correspond to those above described except that the piers constructed on them are made about 21 ft. shorter, vertically, in order to clear the bottom of the lock which rests upon, and is integral with them at this point.

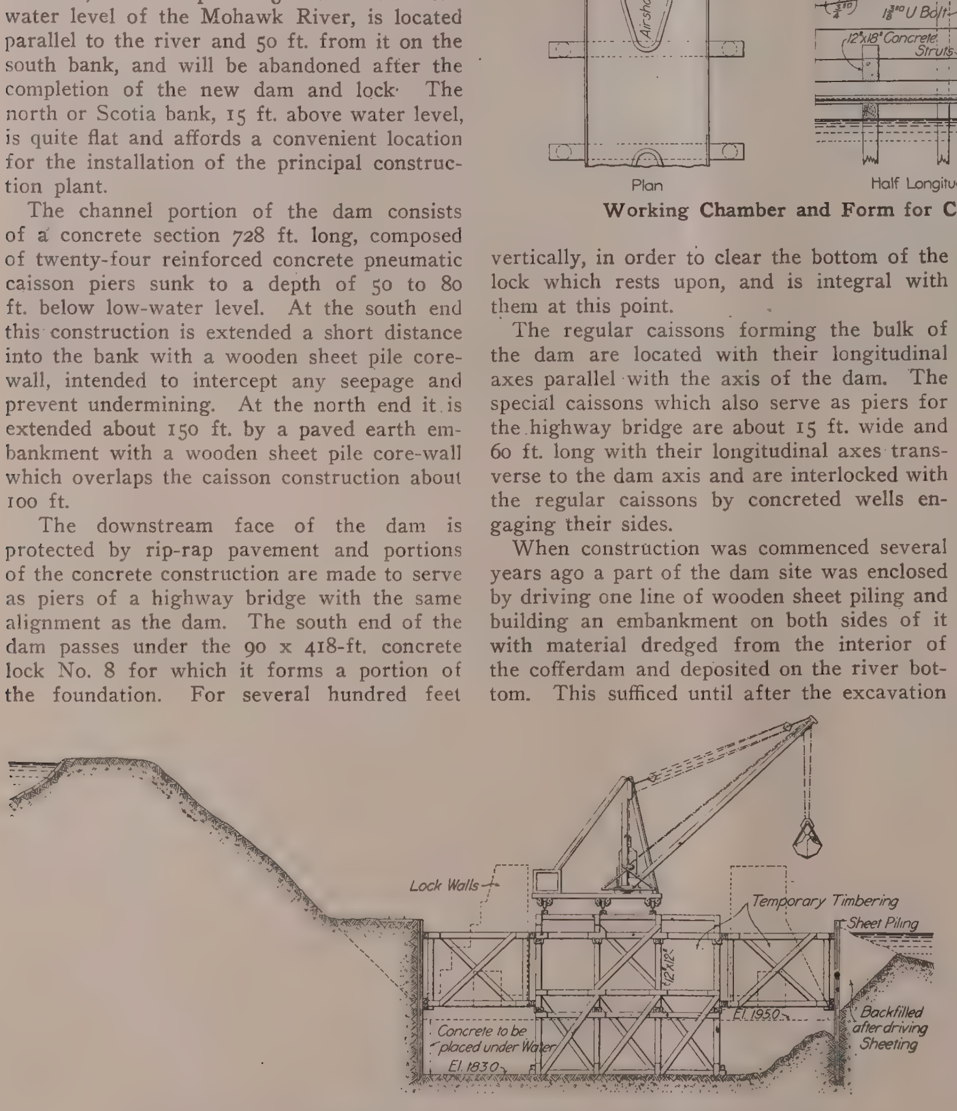


Plan | Half Longitudinal Section | Transverse Section

Working Chamber and Form for Caisson and Supporting Framework

The regular caissons forming the bulk of the dam are located with their longitudinal axes parallel with the axis of the dam. The special caissons which also serve as piers for the highway bridge are about 15 ft. wide and 60 ft. long with their longitudinal axes transverse to the dam axis and are interlocked with the regular caissons by concreted wells engaging their sides.

When construction was commenced several years ago a part of the dam site was enclosed by driving one line of wooden sheet piling and building an embankment on both sides of it with material dredged from the interior of the cofferdam and deposited on the river bottom. This sufficed until after the excavation passed through the thin upper crust of cemented gravel, when the water entered so freely that several 16-in. pumps working a number of months failed to remove it. Little progress was made and the work was finally discontinued.


Lock Walls
Temporary Timbering
Sheet Piling
12"x12"
El. 195.0
Backfilled after driving Sheeting
Concrete to be placed under Water
El. 183.0

Cross-Section through Lock and Cofferdam and Elevation of Bracing

Construction and Sinking of Caissons

After it had been decided to employ pneumatic methods two rows of piles were driven on each side of the dam parallel to and clear of the caissons, to provide for the support, guiding and control of the latter. These piles served as falsework for the platforms on which were assembled the steel cutting edges of the caissons and the wooden forms in which the caissons were cast. The first section, 16 ft. high, was made in two courses of nearly equal depth. In the lower course, reaching up to the top of the working chamber, four steel U-bolts were set and to them were connected tackles suspended from transverse I-beams supported on top of the falsework.

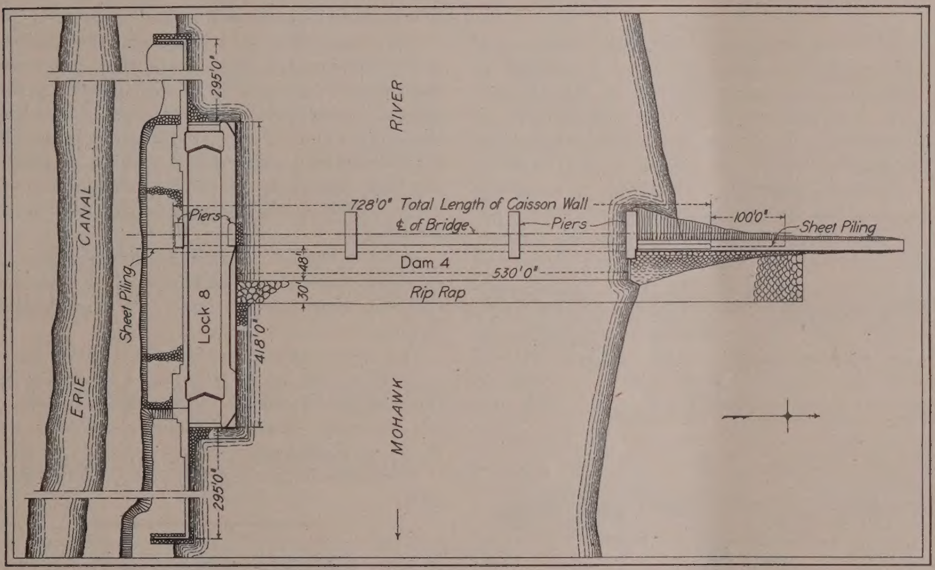
The lead lines from the tackles passed vertically between the pairs of transverse beams and between the pairs of channels forming yokes shackled to the hoisting tackles of the pair of stiff-leg derricks of 10 tons' capacity. The lead lines were provided with clips engaging the top flanges of the beams and yokes and serving as stops to prevent the line from overhauling.

After the concrete in the walls of the working chamber was about 10 days old the derricks were operated to lift the form clear of the scaffold on which it had been assembled and the latter was removed. The clamps which engaged the top flanges of the transverse I-beams were then removed and the derrick tackle was slacked off, lowering the form until the cutting edge of the caisson rested on the river bottom. The sides of the form were built up to keep them always above the surface of the water and the form was pumped out, if necessary, the tackles were detached and concrete was deposited in the form around the airshaft.

Air pressure was admitted to the working chamber, excavation was carried on in it and the caisson was sunk in the usual way, guided by the pile framework enclosing it. The binding and wedging action of the loose gravel on the walls of the caissons made the sinking very difficult and required loads of many tons of cast-iron blocks to force them down. The weight of the pier caissons was considered too great to be advantageously handled by derricks and these caissons were therefore built on artificial islands constructed for the purpose with dredged material dumped on the river bottom in water 10, 15, and 20 ft. deep.

The 55,000-yd. excavation for the lock is being made by special clam-shell buckets operated under water. A large part of it was accomplished before the construction of the wooden cofferdam, which both serves to retain the sides of the excavation and acts as part of the form in which the concrete is deposited. A pile trestle about 500 ft. long was built on the axis of the lock and a parallel track was laid on the bank between the lock and the Erie Canal. Locomotive cranes with 50-ft. booms, traveling on the trestle and track, operate 1¼-yd. clam-shell buckets which excavate the material and deliver it to dump-cars alongside.

As fast as the main excavation is carried about 16 ft. below low-water level in the center of the lock, the trestle bents are successively removed from the rear end and replaced by the framed falsework shown in the transverse section illustrating the second stage. One each side of the falsework sections of braced wooden framework with two rows of horizontal rangers attached to the exterior faces to receive the cofferdam sheeting are floated into position and made fast to the center falsework.



Location of Dam Caissons Acting as Bridge Piers

A stiff-leg traveling derrick is installed on a broad-gage three-rail track, laid on the falsework, and it operates a clam-shell bucket by which the remaining lock excavation is made simultaneously with the driving of the 12 x 12-in. splined sheet piles which enclose the lock excavation and form the cofferdam.

After the completion of the excavation concrete will be deposited to a depth of 12 ft. under water by tremie towers to seal the bottom. The cofferdam will be unwatered by centrifugal pumps and the remainder of the concrete for the bottom and sides of the lock will be deposited in the dry, the side walls being built in forms in the usual manner.

Concrete Plants

The concrete is made with Helderberg Portland cement, sand, and gravel dredged from the excavation and washed with a hydraulic jet into a Stephens-Adamson washing machine with a revolving cylinder. The sand is delivered from the cylinder to a tilting bucket from which the water overflows. When the bucket is filled with sand it automatically discharges through a chute to the storage pile and thence is transferred by cars to the mixer. The transfer cars are drawn up an incline by a hoisting engine and delivered to a storage bin of 800-yd. capacity at the concrete plant. The gravel is handled in a similar manner.

The storage bins supply the charging hopper of a mixing machine delivering to the hoist of a Lakewood tower, 150 ft. high, from which the concrete is chuted for 500 ft. in both directions for the lock and a large portion of the dam. The chute is supported by cables carried by the main tower and by three auxiliary towers 80 ft. high. A smaller concrete plant was established on the north bank of the river to provide for the construction of the caissons at that end of the dam.

Equipment and Principal Quantities

The large amount of plant installed includes two washing and screening machines, one on each side of the river, three Lakewood and Smith concrete mixers, two Brownhoist traveling cranes, three large and three small sheet pile steam hammers of Vulcan, Goubert, and Arnot makes, ten stiff-leg and two guyed wooden derricks with Lidgerwood, Lambert, Mundy and American Hoist & Derrick Company's double and three-drum hoisting engines, two 36-in. Vulcan locomotives, twenty-one 3 and 4-yd. wooden side-dump cars, one floating pile-driver drop hammer tower, one floating barge and derrick, one McKiernan and four Ingersoll-Rand air compressors, with a combined capacity of about 7500 cu. ft. of free air per minute, two steam boiler plants with a total capacity of 1200 hp., and several steam piston centrifugal pumps.

The principal quantities include about 16,500 yd. of pneumatic caisson concrete, about 45,000 yd. of other concrete, 17,000 yd. of caisson excavation, 55,000 yd. of dredge excavation, 8000 yd. of rip-rap, 25,000 yd. earth embankment, 500,000 ft. of caisson timber, about 1,500,000 ft. of other timber, and 360 tons of reinforcement steel. The work is now about 60 per cent completed and is being executed by an average force of about 300 men divided into three shifts.

The work is being executed under the direction of Mr. John A. Bensel, state engineer, by the Foundation Company, of New York City. Mr. L. L. Brown, vice-president of the company, is in charge.

The Longest Direct Transmission Line in the world is a part of the hydroelectric development operations of the Southern Sierras Power Company in California. This line, which will transmit energy from Bishop, Cal., to San Bernardino, a distance of 238 miles, will be operated at 150,000 volts, which is the highest voltage in commercial use.

Timbering and Draining Covered Subway Trench in Quicksand

Contract section No. 1 of the Lexington Avenue subway extends for about 2000 ft. on Church Street, New York, and is a two track standard steel bent structure about 30 ft. wide and 19 ft. high except at two stations, where the average width is about 50 ft. The principal quantities involved in its construction are about 99,000 yd. of earth excavation, 20,000 yd. of concrete masonry, 22,000 sq. yd. of waterproofing, 2357 tons of steel and about 19,000 ft. of sewer pipes from 15 to 48 in. in diameter. The street has a width of 42 ft. between curbs and the soil is a very fine sand mixed with clay which becomes quicksand when wet. At the commencement of operations the ground-water level was about 12 ft. below the surface of the street.

Excavation

The subway is to be constructed in a covered trench having an average depth of about 24 ft. which, near the middle point of the section is accessible through a shaft surmounted by an overhead platform with offices, electric derricks and storage bins, enabling operations to be carried on with a small amount of street obstruction. The general character of the operations is similar to that adopted for other sections of this work, but differs from it materially in some of the details of timbering, excavation and drainage.

Over the trench the street, instead of being carried on heavy longitudinal deck planks supported on transverse timbers close together, is carried on 2-in. transverse planks laid on 6 x 8-in. longitudinal timbers, 4 ft. apart, that rest on 12 x 12-in. transverse timbers 5 ft. apart, thus providing a comparatively thin wearing surface which can be renewed with small waste and has the advantage of providing ventilation around the supporting timbers and thus diminishing their decay. The deck timbers and planks are laid in advance of the excavation, and as the latter progresses, they are carried by vertical posts and transverse timber bents 10 ft. apart, set midway between the permanent steel bents.

The excavation is made in four full width lifts protected by 3-in. tongue and groove sheet piling and timbered with 12 x 12-in. vertical posts and beams. The center portions of the sills in the upper story of timbering are reinforced by 12 x 12-in. pieces 14 ft. long with their ends mitered to engage 12 x 12-in inclined posts with their feet supported on the sills of the second story bents, thus supplementing the intermediate vertical posts and forming potential trusses intended to insure the safety of the street supports should any of the lower sections of the vertical shores be impaired or displaced.

Spoil

Spoil is delivered to an electrically operated belt conveyor about 25 ft. long, installed in the second lift, which discharges into 1-yd. buckets on dump cars in the third lift. These buckets transport the spoil to the hoisting derrick in the shaft.

Before the third lift is excavated hollow sectional steel piles are jacked down below subgrade to carry the paving, the substructures and the street, and prevent any danger of undermining by the operations in the unstable sand. The third lift, about 10 ft. deep, is drifted full width under the floor laid on the second lift, and the spoil is removed on cars at that level. Excavation is carried to subgrade by the fourth lift, about 3 ft. deep, made with a center ditch 5 ft. wide, which affords a drainage channel and permits the ground to dry out and become much more easily handled.

Drainage

The large amount of ground-water encountered makes the sand very treacherous and difficult to handle, so that extensive drainage provisions were made in advance of the excavation. Near the shaft a pit was sheeted down as far as convenient and in it four 18-in. pipes about 5 ft. apart were driven to a depth of 36 ft. below the surface. The bottom of each pipe was perforated and into it was lowered a 6-ft. length of 12-in. strainer pipe. Gravel and broken stone were filled into the annular space between the inner and outer pipes and a 3-in. suction pipe was inserted in each of the strainer pipes. These were coupled to a 4-in. pump that has been operated continuously without drawing much sand.

About 50 ft. from this pit a sump 5 ft. in diameter was sheeted down with Lackawanna steel sheet piles to a depth of about 4 ft. below the bottom of the trench and another 4-in. pump was installed there. These two pumps have lowered the ground-water level about 12 ft. and maintain it at that elevation.

The work is being executed under the direction of the Public Service Commission, of which Mr. Alfred Craven is chief engineer and Mr. Robert Ridgway engineer of subway construction, by Frederick L. Cranford, Inc.

Reinforcing a Vibrating Floor

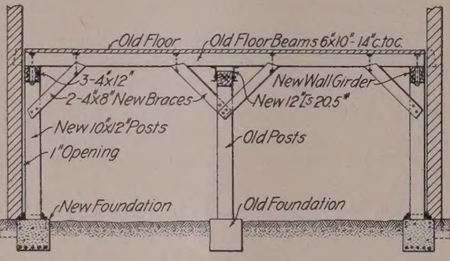
Recently a brick building on Broad Street, New York, was condemned on account of the damage and danger resulting from the operation of ten printing presses on the main floor which produced vibrations extending into the adjacent buildings. This was so serious that the owner refused a renewal of his lease to the printer, who had been operating there for twenty years or more. Mr. Maurice Deutsch, consulting engineer, of New York, was retained and designed a reinforcement which upon execution so greatly reduced the vibrations as to render them harmless and enabled the tenant to renew his lease, thereby saving him and the owner from considerable loss.

The single-piece floorbeams extended across the full transverse width of the building, with end bearings in the brick walls about 25 ft. apart in the clear and a center bearing on a longitudinal 12 x 12-in. wooden girder supported on wooden columns in the cellar. The wooden girder was badly checked and the floorbeam bearings on it were made with loose wedges. Many of the floorbeams had been partly burned and seriously weakened and the floor had sagged badly.

One of the heaviest presses was located opposite the cellar stairway, where the ends of the floorbeams were loosely supported on an insufficient header beam. The presses were loosely connected to the floor and moved as much as ¼ in., while the entire floor moved about the same amount laterally. Its sagging and vibration caused a great deal of noise and squeaking and produced annoying vibrations in adjacent buildings, in which some of the columns and floorbeams were loosened.

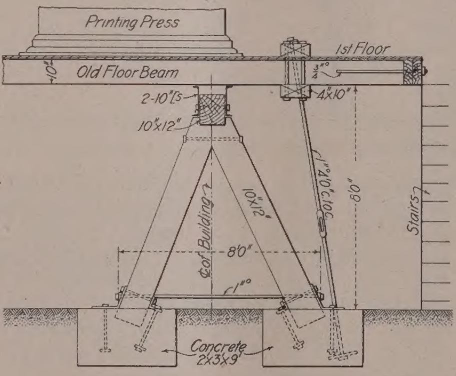
After inspection the floor was pronounced unsafe and there was believed to be danger of its collapse. The difficulties were remedied by reinforcing the center longitudinal girder and supporting the floor on it and on additional supports, making it entirely independent of the wall supports.

The stairway header was reinforced by a heavier new 6 x 10-in. timber bolted to the center longitudinal girder with ¾-in. transverse rods, intended to reduce the lateral bending of the girder caused by the operation of the press. As this proved insufficient, the press was additionally supported by a pair of A-shaped vertical bents 4 ft. apart, set under it, engaging the longitudinal girder and supported on two new concrete footings, to which the press was also bolted by adjustable inclined rods. The footings were built in pits excavated to the elevation of the wall footings and lined with sheet piles driven 2 ft. deeper in order to insulate them more from the adjacent earth and prevent the direct transmission of vibrations to the side walls. These precautions practically stopped the vibration of this press.



Independent First-Floor Support

A pair of channels was bolted to the center longitudinal girder, projecting above its upper surface with the flanges bearing against the underside of the floor beams and thus receiving the load of the latter directly and eliminating the wooden wedges and shims previously used. The wall ends of the floorbeams were supported, independent of their old wall bearings, on new longitudinal girders seated on vertical posts 10 ft. apart on centers with new concrete footings below the cellar floor level. The floorbeams were kneebraced to these columns and to the old center columns, thus forming a rigid independent first-floor platform that does not touch the old walls and is supported on independent new foundations.



Bracing under Press Opposite Stair Well

The changes have reduced the vibrations from about ½ in. to 1/64 in., so that the presswork is now carried on without annoyance to the tenants of this or of adjacent buildings, and it is believed that there is no longer danger there from the reduced vibrations.

Steel Towers supporting electric-power transmission lines are extensively used by forest rangers as fire lookout stations on national forests. With the harnessing of the mountain streams a network of these lines is gradually being woven over the forests, and in the absence of other convenient lookouts the rangers find the steel towers helpful in their fire-patrol work.

Report on the Binghamton Fire

About 2:30 p. m. Tuesday, July 22, fire was discovered in the four-story brick factory of the Binghamton Clothing Company, at Binghamton, N. Y., and in about twenty minutes the building had been completely destroyed. Many employees were caught on the upper floors and were unable to escape, and about forty lives were lost. All but two of the victims were women.

An investigation of the disaster was made by Mr. James P. Whiskeman, advisory engineer to the New York State Factory Investigating Commission, and in his report to the commissions he reaches the conclusions that

(1) Simple and ordinary precautionary measures against the outbreak of fire by the removal of readily preventable causes were neglected.

(2) Waste materials, cuttings and rubbish must be removed from the floors of factory buildings and stored in fireproof receptacles, which should be emptied daily; all factory floors should be swept at least twice a day.

(3) Automatic sprinklers are essential.

(4) Efficiently organized fire-drills and fire departments equipped with auxiliary fire-fighting apparatus are necessary; fire-drills should be conducted at frequent intervals with special regard to the exit facilities, so that if one exit should be cut off the efficiency of the drill and the opportunity for escape may not be lessened.

(5) Proper and sufficient exit facilities are essential; all factory buildings of two or more stories should have at least two efficient exits remote from each other.

(6) Stairways in all factory buildings of two or more stories should be inclosed, interior stairways being inclosed in partitions of fire-resisting materials, and provided with doors of similar materials.

(7) Outside fire-escapes are utterly inadequate.

Book Reviews

A valuable "Bibliography of Smoke and Smoke Prevention," being Bulletin 2 on "Smoke Investigation," has been compiled by Mr. Ellwood H. McClelland, technology librarian of the Carnegie Library of Pittsburgh, and is issued by the Mellon Institute of Industrial Research of the University of Pittsburgh. It is stated in the introduction that a thoroughly satisfactory classification is impossible because only a relatively small number of articles deals definitely with specific problems. Nevertheless, the articles are grouped, the principal divisions being sources of smoke, composition and properties, observation and measurement, effects, prevention, work of organizations, the smoke problem in special localities, legal aspects in general, and laws and ordinances in various states and countries. The bibliography contains 164 pages. (Pittsburgh, University of Pittsburgh, 50 cents.)

"Some Facts About Treating Railroad Ties—Parts IV, V and VI" is the title of a pamphlet by Mr. W. F. Goltra, president of the W. F. Goltra Tie Company. The pamphlet is for the greater part a reprint of papers and discussions presented January last at the ninth annual meeting of the American Wood Preservers' Association. These reprints are "A Comparison of Zinc Chloride with Coal Tar Creosote for Preserving Cross-Ties," by Mr. Howard F. Weiss, director of the Forest Products Laboratory at Madison, Wis., and Mr. Goltra's discussion of the paper; Mr. Goltra's "History of Wood Preservation," and the paper by Mr. David Allerton on the "Preliminary Treatment of Timber to Insure a More Even and Satisfactory Impregnation with Creosote." There are also given a list, map and brief tabulated description of the timber-treating plants in North America and brief descriptions of the principal processes. (Cleveland, Ohio, The W. F. Goltra Tie Company.)

The Year Book of the New York Society of Architects for 1913 has just been issued. A few of the new features in this edition are a complete list of practising architects in New York State, a chapter devoted to the personnel of New York State and New York City departments and bureaus, a checking list for specification writing, and the re-paragraphed building code. The latter has been printed on pink paper so as to be easily distinguishable. The changes that have been made during the year in the building laws, such as amendments to the labor law in regard to the construction of factories and tenement houses, are included in the new edition. Besides these improvements, the Year Book has a quantity of useful tables and data that make it essentially an architect's handbook. It is bound in black leather with flexible covers and gilt edges and contains 306 pages of text. It is given free to the architects of New York City, but a nominal charge of $5 is made to others. (New York, New York Society of Architects.)

Letters to the Editor

Flood Control in Sacramento Valley

Dear Sir: A reference in the Current News Section of the Engineering Record of Aug. 16 to flood control in the Sacramento valley, California, says: "The Hall plan of 1890 reported in favor of enlarging the river channels to carry all of the flood waters. The Manson-Grunsky by-pass plan, made in 1894, advocated the by-pass method; that is, the carrying of the flood waters through channels formed by parallel levees in the flood basin. A third report was rendered in 1904 by a commission of engineers, known as the 'Dabney Commission.' This plan again recommended the main channel method. The latest and most thorough study of the problem now proposes the by-pass method of treatment."

Please allow me to say that the plan of the Dabney Commission was in brief (1) to compel the main channel to carry a larger volume of flood water than had ever before been conveyed by it, by means of levees parallel with the river, so located as to increase the effective width for flood discharge; (2) to provide waste weirs in the levees at selected points, to void the surplus flood water, and temporary by-passes along the lines as described for the present plan, to convey the surplus water into Suisun bay; and (3) progressively to enlarge the discharge capacity of the main channel by both natural and artificial agencies until it should contain the whole flood flow.

Whether the last named feature is part of the present plan or whether the by-pass system is to be perpetuated, the writer is not informed.

It should be stated, however, that upon such data as were then obtainable the Dabney Commission was led to conclude that the maximum flood flow in the Sacramento valley would not exceed 300,000 sec.-ft., whereas, measurements of the flood flow of the great flood of 1907, made by the U. S. Geological Survey, gave a total volume of flow down the Sacramento valley that year of more than double the above figure, a result which greatly magnifies the problem, as it was then contemplated.

T. G. Dabney,
Chief Engineer, Yazoo-Mississippi Levee District.
Clarksdale, Miss.

Stresses in Circular Tubes

Dear Sir: The author of the article, "Stresses in Circular Tubes," published on page 649 of your issue of June 14, makes the statement that "the lack of satisfactory formulæ . . ." On pages 482, 483 and 484 of Church's "Mechanics of Engineering" is given a reasonably clear discussion of nearly every item taken up in your issue except the non-symmetrical case. It seems certain from wordings appearing in his discussion that the writer of your article knew of the existence of some of the former papers but he fails to acknowledge their existence in any satisfactory way, nor does he give credit to such men as Professor Benjamin, William H. Searles, Edwin J. Fort and Prof. I. P. Church for their pioneer work in this very complicated mathematical field.

Philadelphia. C. W. L. Filkins.

[Mr. Filkins' letter was submitted to Mr. Haukelid, whose reply follows.—Editor.]

Dear Sir: Mr. C. W. L. Filkins says in a letter to the Engineering Record that Professor Church's "Mechanics of Engineering" gives a reasonably clear discussion of nearly every item taken up about stresses in circular tubes except the non-symmetrical case, and also that it seems certain that I knew of the former papers on this subject but failed to acknowledge same and therefore did not give credit to such men as Prof. Benjamin, William H. Searles, Edwin J. Fort and Prof. I. P. Church for their pioneer work.

When I was confronted with the problem of figuring stresses in circular tubes, I found that Professor Föppl, of Munich, in one of his volumes, had treated a ring subject to a single load on top. Professor Föppl figured the moments at the ends of the vertical and horizontal diameters; he also gave the elongation of the horizontal diameter for their single load on top of the tube. But this far from covered the field that was needed in my case, and it was therefore necessary to figure out the moments and deformations of circular tubes subject to different kinds of loadings, such as (a) concentrated loads placed at any point symmetrically about vertical diameter; (b) uniform load per linear foot; (c) combinations of these loadings along vertical and horizontal diameters of the tubes and other useful information as given in the tables; (d) finally non-symmetrical cases.

That Prof. I. P. Church had treated some of the problems, except the non-symmetrical case, is news to me, since I have never read his book. I did not know about the work of Professor Benjamin, William H. Searles and Edwin J. Fort.

Björgulf Haukelid.
Telemarken, Norway.

Proposed Canadian Institution of Municipal Engineers

Dear Sir: I have received letters approving of the idea of forming an Association of Municipal Engineers, and as the Canadian Public Health Association meets in Regina, Sept. 18, 19 and 20, and many engineers from various parts of Canada will attend, the suggestion has been made to me that an informal meeting of those engineers interested in the proposal be held, to discuss the question.

If this suggestion is an acceptable one, an informal meeting will be held during the convention, due notice of which will be given at one of the general sessions.

It will be very desirable if the leading municipal engineers can be present, so that the matter shall be discussed as fully as possible. If those who cannot be present will kindly write me stating their views, I will undertake to submit them to the gathering.

R. O. Wynne-Roberts,
Regina, Sask. Consulting Engineer.

Value of the Classics in Modern Education

Dear Sir: The address upon the value of the classics in modern education, delivered recently by Dr. Charles P. Steinmetz, published on page 158 of your issue of Aug. 9, is an able presentation of the arguments in favor of the humanities in education. It has been the writer's observation during some twenty years of teaching experience that, as a rule, those students who have had thorough mental training before undertaking the technical subjects of engineering accomplish much more than those who lack such discipline. He would therefore heartily concur in Dr. Steinmetz's statements in that regard, in so far as they relate to the great value of prior mental discipline, but he can not agree that such discipline is found alone in classical study, nor even that classical study is better or necessary. That the study of the ancient languages and literature forms a very valuable adjunct to one's education, that it broadens the view and refines the taste, cannot be denied, but when the claim is advanced that it is a sine qua non or even a necessity in engineering we must dissent, however valuable we admit the study of these languages to be.

Education is a developing process principally and whatever compels thought develops the mind through exercise. It has an educational value, no matter whether it be Horace, Thucydides and Homer, or bridge engineering, masonry construction and steam engines. It does not depend on the subject matter so much as how that subject matter is presented and how the student is made to approach and grasp it. In the hands of some teachers the study of Greek and Latin degenerates into mere parsing of forms and digging of roots, disclosing none of the beauties of the languages. The effect is to deaden the interest and create disgust. On the other hand the study of the most technical subject to-day may be made so inspiring as to call forth and develop the highest qualities of self-reliant manhood and womanhood. It all depends upon the personality of the teacher and, properly presented, any subject in the average college curriculum of the present may be made cultural and may have an educational value by no means second to that of the classics.

While we would not in any sense under-value the worth of classical study and while we would advise any young man or woman who has the time and means to pursue those subjects to do so, it is nevertheless true that the same culture and the same mental discipline can be had without them as with them. In short, the defect in our modern educational scheme, if such defect exist, is not so much one of subject matter as of method of teaching it. All subjects are both cultural and utilitarian at the same time. There is no such thing as pure culture apart from utility, and the trouble is that we are in danger of losing sight of the cultural value of technical subjects. We are emphasizing their money-making value, turning out trained machines instead of educated men, substituting "rule of thumb for reign of thought." This is a real danger in modern education and as a warning against such danger Dr. Steinmetz's address is especially timely and valuable.

Lebanon, Tenn. WALTER H. DRANE.

Graphical Analysis of Double-Reinforced-Concrete Sections

Dear Sir: The following discussion and diagrams offer a graphical solution for the problems arising in the design of double-reinforced-concrete sections. The need for compression reinforcement in concrete beams does not occur in the larger number of structures, but conditions are occasionally met with that require just such treatment. The formulæ used in the computation of this reinforcement are complicated, involving tedious trial calculations; and with the view of eliminating the labor involved in their use, the accompanying short graphical solution of the fundamental equations is presented.

The notation employed is identical with that used in Turneaure and Maurer's "Principles of Reinforced-Concrete Construction," and the four quadrants simply present the four essential formulæ in graphic form, placed adjacent to each other for rapid manipulation. These formulæ, according to Prof. A. N. Talbot's theory of parabolic stress variation, are as follows:

$$f_s = n\,\frac{1-k}{k}\,f_c\,\frac{2}{2-q} = \frac{1-k}{k-d^1/d}\,f_s^1.$$

where

$$d^1/d = 0.1 \text{ and } n = 15.$$

$$k^2(3-q) + 6kn(p+p^1) = 6n(p+d^1/d).$$

$$x = \frac{\frac{4-q}{4(3-q)}k + d^1/d \times C^1/C}{1+C^1/C}\,d;$$

$$C^1/C = \frac{6p^1n(k-d^1/d)}{(3-q)k^2}$$

$$j = 1 - x/d \qquad R = f_s pj.$$

For the straight line theory the following formulæ are used:

$$f_s = n\,\frac{1-k}{k}\,f_c = \frac{1-k}{k-d^1/d}\,f_s^1$$

where

$$d^1/d = 0.1 \text{ and } n = 15.$$

$$k = 2\sqrt{6(p+p^1) + 24(p+p^1d^1/d)} - 12(p+p^1)$$

$$x = \frac{k/3 + d^1/d \times C^1C}{1+C^1/C}\,d$$

where

$$C^1 = \frac{30p^1(k-d^1/d)}{k^2}$$

$$j = 1 - x/d \qquad R = f_s pj$$

In developing the formulæ according to Prof. A. N. Talbot's theory it is assumed that the ultimate stress on the materials exists when $q = 1$. In the diagram, however, an average value of $q = 0.7$ for concrete stresses from 1600 to 2000 lb. per square inch was used, as more nearly representing actual conditions. It was considered that since a greater factor of safety is applied to the concrete than to the steel the stress on the concrete will not have reached its ultimate value when the steel has reached its elastic limit.

The small diagrams in the lower left-hand corners illustrate the method of using the main diagrams.

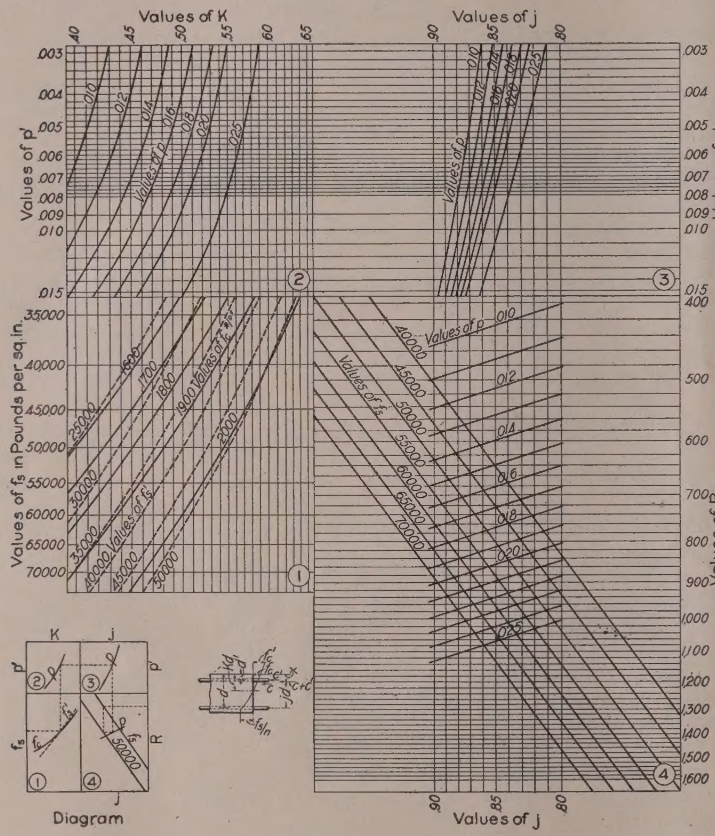
Quadrant 1 determines the position of the neutral axis and the compressive reinforcement stress for any assumed unit stresses in the tensile steel and the concrete.

Quadrant 2 gives simultaneous values of the percentage of compressive and tensile reinforcement for values of k obtained in quadrant 1.

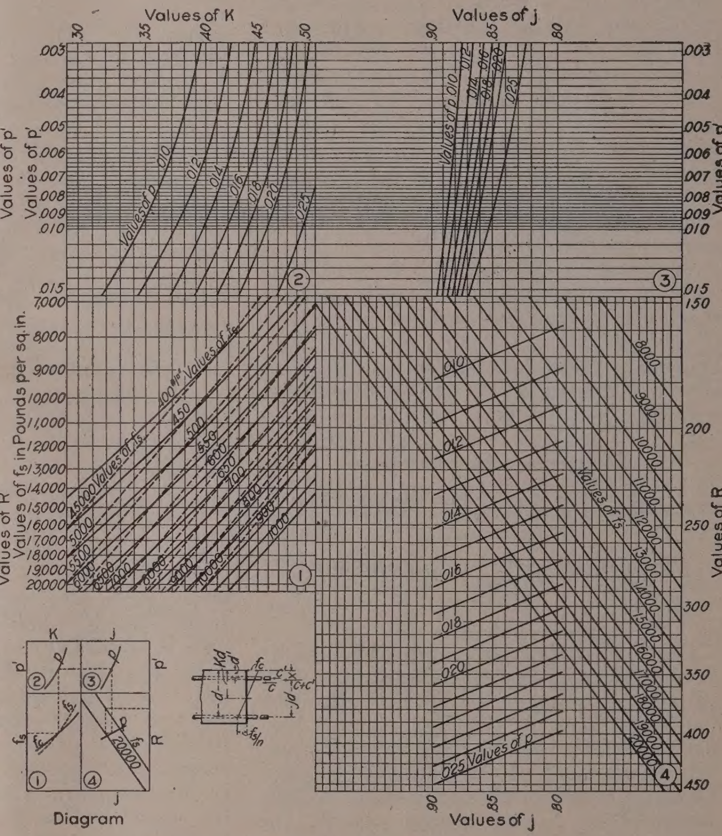
Quadrant 3 gives the corresponding values of j, and hence the lever arm jd for the same values of percentages of reinforcement used in quadrant 2.

Quadrant 4 determines the value of R, the resisting moment factor, for values of lever arm, percentage and tensile steel stress determined or assumed in the first three quadrants.

Chicago, Ill. SAMUEL KLEIN.



Ultimate Stresses, Professor Talbot's Theory



Working Stresses, Straight-Line Theory

THE MELLEN AUTOMATIC-STOP COMPETITION which closed recently brought forth 2816 contestants for the $10,000 prize, the applicants representing all parts of the world, including China, Japan and Australia. Of the 2816, 704 sent plans or models. While most of the devices show a total disregard of some of the eighteen requirements specified in the circular sent out, tests will be made at once on the most meritorious devices, beginning with one invented by Mr. Gene Webb and owned by the International Signal Company, and one invented by an engineer of the Union Switch & Signal Company. Both devices use a third rail for the current, and both will be tested on the Delaware, Lackawanna & Western Railroad, the tests probably taking a year, in order to bring all sorts of weather conditions into play. No award can be made until the end of 1915, as the contestants have until then to perfect their apparatuses.